Financial Tradeoffs Associated With Timber Sale Payment Methods: Evaluating St. Louis County Land Department's Timber Sales Program

by

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Executive Summary

In spring 2013, the Environment and Natural Resources Trust Fund contracted with the University of Minnesota to evaluate timber payment method's impact on the cost-effectiveness of Minnesota's public timber sale program. The two timber payment methods used in Minnesota are the consumer scale and sold on appraised volume (SOAV). For timber sales using the consumer-scale timber payment method, the buyer pays for each unit of volume removed from the tract[1], regardless of the tract's estimated volume. For timber sales using the SOAV timber payment method, buyers pay for the entire tract's estimated volume, regardless of the amount of timber actually harvested. This study focuses on how the selection of timber payment method influences the gross timber sale revenue and the total administrative costs within the St. Louis County Land Department (SLCLD). Through the analyses on gross timber sale revenue and total administrative costs, the study illustrates the financial tradeoffs associated with timber payment method and explores ways to improve the cost-effectiveness of managing public timber programs.

The study contains the following components:

1. Empirical analyses to understand how timber payment method influences overall gross timber sale revenue on SLCLD timber sales.

2. Assessment of how timber payment method impacts the administrative costs of the SLCLD's timber program.

3. Cost-effectiveness summary of timber payment method within the SLCLD that utilizes the findings from the analyses on gross timber sale revenue and total administrative costs.

4. Sensitivity analysis to evaluate how timber payment method's influence on the cost-effectiveness of timber sale programs might vary between public timber sale programs.

These analyses are summarized below.

Gross Timber Sale Revenue

A key aspect of public timber management programs is to understand the factors that drive gross timber sale revenue—the total revenue received before any expenses are deducted. The assessment uses timber sale data provided by the SLCLD to conduct hedonic price analyses, which explores timber payment method's influence on gross timber sale revenue and willingness to pay[2] (WTP) for timber. In addition, an experimental technique called paired bidding was conducted to assess timber payment method's influence on WTP for timber. These analyses found that timber payment method did not significantly influence a bidder's WTP for timber or the overall gross timber sale revenue generated on SLCLD timber sales.

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[1] A tract is a parcel of timber land.
[2] Willingness to pay is the maximum value an individual is willing to give to receive a good or service.

Total Administrative Costs

There are operational aspects of administering each timber payment method that are similar; however, the analysis focuses on the timber sale administrative features that distinguish each payment method. For most public agencies, there are cost areas that vary based on the timber payment method used, which includes the timber cruise (i.e., timber sale volume appraisal), consumer-scale ticketing process, and the in-woods agency scaling. Some agencies spend more administrative resources timber cruising tracts that use the SOAV timber payment method; however, the SLCLD has the same cost of timber cruising for both payment methods, so the SLCLD has no cost differences between timber payment methods attributed to timber cruising. The consumer-scale ticketing system is administered by the seller to track each load of wood leaving the harvest site; on the other hand, the SOAV timber payment method does not require a ticketing system. The cost of maintaining this ticketing system are estimated and added to the total cost of the consumer-scale timber payment method system. Lastly, the administration of the in-woods agency scaling, whereby the agency manually scales the harvested volume on timber sales, is an additional cost for the consumer-scale timber payment method. The SOAV timber payment method does not require in-woods agency scaling. The results of the total administrative cost differences for the SLCLD indicate that consumer-scale timber payment method costs approximately $323.06 more per sale compared to the SOAV timber payment method. In addition, the total cost difference of the SLCLD's consumer-scale timber payment method is approximately $37,765 higher per year than the SOAV timber payment method.

Cost-effectiveness Summary

The cost-effectiveness summary illustrates the financial tradeoffs between timber payment methods by estimating the net timber sale revenue (i.e., gross timber sale revenue minus total administrative costs) for SOAV and consumer scale. Since the analysis on gross timber sale revenue indicates no difference between timber payment methods, timber payment method only influences the net timber sale revenue of a public timber program through total administrative costs. The total administrative cost analyses indicate that each SLCLD consumer-scale sale costs an estimated $323.06 more than a comparable SOAV sale. Therefore, the consumer-scale timber payment method is slightly less cost-effective than the SOAV timber payment method within the SLCLD.

Sensitivity Analysis

Timber payment methods vary widely among timber sale programs in their implementation and efficiency; therefore, the cost-effectiveness summary of the SLCLD timber sale program is used to develop estimates of agency costs under a range of cost assumptions. Several cost scenarios are provided to highlight the program-specific differences of timber payment method's influence on cost-effectiveness, since the implementation of timber payment method looks different for each public agency. The analysis explores hypothetical higher and lower cost timber programs, as well as an estimated cost scenario for the Minnesota Department of Natural Resources (MN DNR). These scenarios are used to illustrate how the total administrative costs related to timber payment method change under different assumptions. The results of the sensitivity analysis indicate that three of the four cost scenarios have higher costs for the consumer-scale timber payment method as compared to SOAV timber payment method. The MN DNR cost scenario has higher costs for the SOAV timber payment method, but the administrative cost difference is

only $20.97 higher for SOAV timber sales. While the total administrative cost differences between the two timber payment methods varied between cost scenarios, all four cost scenarios have relatively small administrative cost differences, suggesting an insignificant financial tradeoff between timber payment methods.

1. Introduction

Minnesota's public forests play an important role in sustaining the state's economy. In 2012, these forests supplied approximately 60% of Minnesota's total timber harvest (Minnesota DNR, 2013). The approximately 1.65 million cords[3] of public timber harvested annually in Minnesota is an important raw material to the state's fifth largest manufacturing sector—the forest products industry (Minnesota DNR, 2014). Timber sales on public forest land in Minnesota produce substantial revenues for federal, state, and local governments. Deckard and Skurla (2011) report that public agencies in Minnesota averaged approximately $44 million in annual gross timber sale revenue from 2009-2011. The revenue generated from public timber sales helps support Minnesota's K-12 educational system and county/municipal governments (Brown et al., 2010). Timber sales also help achieve silivicultural[4], vegetative management, and wildlife habitat objectives (Brown et al., 2010).

Another important aspect of public timber sales that can have a substantial impact on net timber sale revenue is the method used to collect payment from the timber buyer (i.e., timber payment method) (Brown et al., 2010). Public agencies generally collect payment for timber sold in one of two ways: consumer scale or sold on appraised volume (SOAV). For timber sales using the consumer-scale timber payment method, the volume of wood harvested by the buyer and transported to a consumer from a tract is measured (scaled) by the seller (or a third party) and the buyer pays a specified amount (i.e., its sale price) for each unit of volume brought to a consumer (Brown et al., 2010). In contrast, buyers using the SOAV timber payment method pay a specified amount for the entire tract of timber, regardless of the amount of timber actually harvested from the tract and brought to a consumer (Brown et al., 2010).

This study investigates how the timber payment method impacts the cost-effectiveness of SLCLD's timber sale program. Cost-effectiveness analysis of public timber sale programs assesses the revenue and costs associated with the policies and administrative procedures. By exploring timber payment method's influence on cost-effectiveness, this study provides public agencies and policymakers with information that can help identify the financial tradeoffs associated with these two timber payment methods—an area of research for which little information and analysis exists. Through a better understanding of the financial tradeoffs between these methods, Minnesota's public timber sales programs may be enhanced.

1.1. Background
Timber Sale Process

Public agencies develop and implement plans for the management of public forests that include annual timber harvest goals and objectives. Each timber harvest is carried out as a part of a long-term forest management plan for that tract. The timber sale process begins with sale preparation, wherein a forester marks the boundaries of the sale, estimates (or appraises) the sale's

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[3] Average annual harvest in Minnesota from 2011-2013 (Minnesota DNR, 2014).
[4] **Silviculture** is the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis (Society of American Foresters, 2008).

merchantable volume, and specifies the use of timber harvesting guidelines (e.g., reserve trees[5]) and other harvest regulations (e.g., allowable operating conditions). Most timber programs have timber appraisal accuracy standards[6] that foresters are expected to meet in estimating the tract's merchantable stand volume (Deckard et al., 2011; USFS, 1997).

After the timber sale preparation process is complete, the agency (i.e., seller) markets the timber tracts to prospective buyers by making the tract specifications available through the mail and/or by posting the information online. Tract information typically includes the estimated merchantable volume, species, sale acres, location, sale type (e.g., oral or sealed bid auction[7]), timber payment method, reserve price, harvest specifications, and product types (e.g., sawtimber, pulpwood, bolts, and biomass). Prospective buyers usually have approximately 30 days to inspect the tracts being offered for sale in order to evaluate the quality of the stand and the accuracy of the forester's appraisal. In Minnesota, oral or sealed bid auctions are generally used to sell the timber, with the tract awarded to the highest bidder (Deckard et al., 2011). Buyers must adhere to all contractual requirements such as the timber payment method, amount of payments, use of harvesting guidelines, equipment restrictions, and contract length (Appendix A). These contractual arrangements vary between individual sales and timber sale programs.

Timber Payment Method
An important part of the timber sale process is specifying when and on what basis the buyer pays for the timber. In general, public agencies utilize two types of timber payment methods: SOAV and consumer scale (Brown et al., 2010). There is a third timber payment method used in a few states called shares contract, wherein the buyer and seller split a percentage (e.g., 50-50, 60-40) of the total value of each product after scaling (Stelzer, 2011). SOAV is a timber payment method wherein the buyer pays for 100% of the timber sale's appraised timber volume at a price which is generally determined through an auction process. In consumer-scale sales, the buyer pays for the timber based on the amount harvested and scaled at a mill. Agencies select the timber payment method based on their administrative requirements, and on a variety of economic, social, and ecological factors wherein the agency often has the flexibility to use more than one payment method.

Figure 1 compares the SOAV and consumer-scale timber payment methods used in Minnesota to illustrate important operational differences. Regardless of timber payment method used, the process for setting up a tract of public timber for sale begins with the agency's forester appraising the stand's merchantable volume, marking stand boundaries and conducting related field work, and preparing appropriate paperwork (e.g., documenting harvest specifications, timber payment method). The agency collects a down payment (typically 15%) from the buyer under both timber payment methods on the date of the sale. Under the SOAV method, the buyer must pay for the tract (or harvesting block) in full before removing the timber. The consumer-scale method also requires the buyer to pay for the timber sale's estimated volume in full before harvesting the timber, which can come in the form of cash or a letter of credit from a bank.

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[5] **Reserve trees** are individual live or dead trees that are left unharvested; reserve trees are often used to achieve conservation management goals.
[6] **Timber appraisal accuracy standards** refers to the methods used by public agencies to control the level of error when foresters are assessing the amount of volume on a timber sale.
[7]**Sealed bid auctions** require prospective buyers to submit bids privately and the highest sealed bid wins the sale.

Consumer Scale
(Pay for what is harvested)

Forester appraises the merchantable timber volume within the sale area and prepares appropriate paperwork needed to auction the timber.

↓

Agency sells timber and collects down payment.

↓

Prior to harvesting each block, the agency receives full payment for timber. Seller distributes scale tickets. Buyer uses tickets (two stubs per ticket) to track each load of timber harvested and removed.

↓

Buyer harvests the timber and leaves a stub in a secured lockbox at the site with an estimate of volume on each truck load.

↓

Forester collects lockbox scale tickets from the lockbox while administering the timber sale.

↓

Destination scale ticket stub for tracking volume is collected by the purchasing mill for each truckload of wood received.

↓

Destination scale ticket stubs from the purchasing mill and the associated volume scaled by that mill are sent to the agency.

↓

Agency verifies that each destination stub matches the corresponding stub left in the lockbox and enters delivered volume information into a database.

↓

After all contractual obligations have been met, sale volume has been harvested and transported to a consumer, and scale tickets have been accounted for, a refund or invoice for the remaining balance is issued by the agency.

↓

Seller stores scale tickets in storage facility after sale closeout.

SOAV
(Pay for estimated volume)

Forester appraises the merchantable timber volume within the sale area and prepares appropriate paperwork needed to auction the timber.

↓

Agency sells timber and collects down payment.

↓

Prior to harvesting each block, the agency receives full payment from buyer.

↓

Buyer harvests the timber.

↓

Once the buyer indicates the sale has been fully harvested or the contract expires, the seller archives the sale as closed. If the seller has not applied down payment amount to the buyer's final (and full) payment, the seller will refund the amount owed.

Figure 1. Comparison of the consumer-scale and SOAV timber payment methods in Minnesota.

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It is at this point that the timber payment methods diverge. Under the SOAV method, the buyer is not required to track the volume harvested. The consumer-scale method requires the buyer to use a ticketing system whereby timber is tracked from the harvest site to the consuming mill. The buyer fills out a paper "ticket" for each load of harvested timber before it leaves the harvest site. Each ticket has a unique number and contains two stubs: a lockbox stub and a destination stub. The lockbox stub includes information on each hauled load of harvested timber, including the date and time hauled, species mix, approximate quantity of timber hauled, driver's name, and destination of the timber. When a load of harvested timber leaves the harvest site, the completed lockbox stub is deposited in a secured lockbox (usually placed at the site's entrance) and is later collected by the agency forester administering the timber sale. The destination stub is taken with the hauled load to the consumer. In most instances, the consumer will then determine the volume of wood delivered. After the timber is measured by the scaler (e.g., timber is weighed at the consuming mill), the load ticket number and information about the scaled volume of harvested timber on each truck load is sent to the agency. The agency then converts the scaled weight to volume, typically cords. Any harvested volume underruns[8] or overruns[9] by species and product for a tract are reconciled by the agency once the harvest is complete and the timber sale is closed. Timber sale buyers are charged or refunded the difference between the amount they paid to the agency before opening (i.e., beginning the harvest on a timber sale sale) the sale and the value[10] of the timber harvested. The additional administrative processes associated with consumer-scale sales are one of the major differences between the two timber payment methods and are an important area of focus in the analysis of total cost differences.

1.2. Previous Research on Timber Sale Payment Methods

Research on timber payment methods has focused on documenting timber payment method use among public timber sale programs and how timber payment methods impact: program-level financial efficiency, buyers' WTP for stumpage, the total volume harvested, total administrative costs, and financial risk sharing between the seller and buyer. The following summarizes the research conducted in each of these areas.

Timber Payment Method Use
Previous research on timber payment methods suggests that state timber program administrators differ in their use of timber payment method (Brown et al., 2010). A national survey of state timber sale programs found that states use the SOAV timber payment method (63%) more often than the consumer-scale method (37%) (Brown et al., 2010). These two timber payment methods are configured by public timber sale programs in three ways: selling tracts as 100% consumer scale, 100% SOAV, or a blend of SOAV and consumer scale (i.e., blended sales[11]). Program administrators use blended methods to select the optimal timber payment method for each species on a given tract. Several public agencies also give the buyer the option to choose the timber payment method.

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[8] **Underruns** occur when the seller overestimates the volume of standing timber harvested, and the recovered volume is less than expected.
[9] **Overruns** occur when the seller underestimates the volume of standing timber harvested. In this case, the buyer recovers more volume than the appraised volume.
[10] Based on the bid price per unit submitted by the buyer.
[11] **Blended sales** have a portion of the tract volume sold through the SOAV method and a portion sold with consumer scale. Thus the sale contains a blend of both payment methods.

Brown et al. (2010) found that timber payment method use varies among state timber programs and that most state programs utilized either 100% SOAV or a blend of consumer scale and SOAV. Moreover, Brown et al. (2010) stated there was very little agreement among state timber sale program supervisors about the preferred timber payment method. A variety of social, economic, political and ecological conditions unique to each timber sale all can influence an agency's decision on timber payment method (Brown et al., 2010).

Program-level Financial Efficiency
A MN DNR report evaluated the efficiency and effectiveness of SOAV and consumer-scale timber sales (Deckard et al., 2011). This report provided an accounting of the revenue and cost differences associated with each timber payment method. Using historical MN DNR timber sale data (2001-2006), the average bid price for consumer-scale sales was $22/cord and $20/cord for SOAV sales, indicating buyers discounted SOAV bids by 5-15% compared to consumer-scale sales due primarily to the financial risk of volume underrun (Deckard et al., 2011). The report also noted that there was a difference when the seller received payment for timber, as consumer-scale sales provided revenue streams to the seller while the operator was harvesting timber, while SOAV sales realized full revenue for the seller before each unit block was harvested.

The Deckard et al. (2011) report also specified that the total administrative cost for SOAV sales was 20% greater than consumer-scale sales, requiring 12 full time equivalent employees (FTEs) per 100,000 cords compared to 10 FTEs per 100,000 cords required for consumer scaling. The report attributed the increased administrative cost for SOAV sales to increased timber cruising[12] time (Deckard et al., 2011). The report used a combination of timber sales data, time study data, and direct survey information from the MN DNR for the cost analysis. The MN DNR has higher standards for SOAV timber cruising (i.e., ±10% accuracy) as compared to timber cruising on consumer-scale sales (i.e., ±20% accuracy); therefore, staff spend more time appraising SOAV sales. The additional administrative time spent on SOAV sales is to increase the accuracy of the timber appraisal to reduce the risk to the buyer and seller. The report found that in order to meet the MN DNR timber cruising accuracy standards for SOAV and consumer-scale sales, appraisers would need a timber cruising intensity of 1.3 plots[13] per acre for consumer scale and 2.5 plots per acre for SOAV. While the report was informative with respect to highlighting the differences in timber cruising time for each timber payment method on MN DNR sales, it did not provide a comprehensive assessment of the administrative cost differences. For example, the report did not include the total cost of the consumer-scale ticketing process.

Willingness to Pay for Stumpage
A survey reported by Kueper et al. (2014) found that 59% of MN DNR timber purchasers prefer consumer-scale sales and 41.3% prefer SOAV sales. This preference might influence a bidder's WTP for a timber tract and thus impact the gross timber sale revenue generated by the seller. Kilgore and Blinn (2005) reported that a buyer's knowledge of the forester who set up the timber sale might influence their WTP. If the tract was sold under the SOAV method, bidders may base their bidding behavior on the specific forester who appraised the timber tract. Over time, buyers can become familiar with a forester's timber appraisal practices (e.g., tends to underestimate merchantable volume) and use that information to adjust their WTP accordingly (e.g., increase

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[12] **Timber cruising** refers to the process used to appraise the volume by species and product and value of a tract of timber being offered for sale.
[13] Sample plots are established throughout the stand of timber to assess the volume by species and product.

their WTP if the appraiser consistently underestimates the volume of merchantable timber in a timber sale) (Brown, et al., 2010).

Several studies have analyzed timber payment methods and their expected impact on bid price and wood utilization. Flick (1985) highlighted some of the potential tradeoffs between each timber payment method and hypothesized that SOAV sales promote "better timber utilization and tend to elicit higher prices" from buyers (p. 149). Similarly, Maroaka and Watson (1983, 1986) found that use of the SOAV timber payment method by USDA Forest Service reduced administrative costs, produced higher stumpage bids, and encouraged timely harvests. The findings from these two studies contradict the results in the Minnesota DNR report (Deckard, 2011), which stated that SOAV stumpage bids were discounted by 5-15% compared to bids submitted for consumer-scale sales.

Utilization of Merchantable Volume
The choice of timber payment method can create variability in the volume harvested. As mentioned, Flick (1985) hypothesized higher utilization of a tract under the SOAV timber payment method. The buyer using the SOAV timber payment method pays for the estimated volume and can harvest all merchantable volume. Consumer-scale sales require the buyer to pay per unit harvested, so their income largely depends on the difference between the marginal revenue and marginal cost for each unit of timber harvested. It is suspected that under a consumer-scale payment method, buyers may not utilize some material from the tract if the marginal cost of harvesting certain trees, or sections of trees, and transporting that material to market exceeds the marginal revenue. In contrast, the SOAV payment method might drive utilization higher, as any revenue received for additional stumpage (i.e., volume harvested above the appraised cords) represents a higher profit margin for the buyer since there is no stumpage cost associated with the additional timber volume. Because the stumpage cost is fixed regardless of the total volume harvested, a buyer might attempt to achieve a higher rate of utilization under the SOAV method which could, in turn, affect the bidder's WTP.

Total Administrative Costs
In addition to differences in bidder WTP, timber payment method may affect the program's cost of administering a sale. The consumer-scale timber payment method requires a ticketing system whereby the seller tracks each load of wood leaving the harvest site. Conversely, the SOAV method does not require a ticketing system. Therefore, many public timber sale program managers believe that SOAV sales have lower administrative costs, because they do not have to spend resources administering a ticketing process (Brown et al. 2010). Another potential administrative cost difference is time spent appraising tracts for sale (i.e., timber cruising). Since the buyer of a timber sale using the SOAV method pays for the stand's appraised volume regardless of the amount of timber actually removed, some agencies may spend more time in the field appraising SOAV timber tracts to minimize their risk of underestimating the sale's timber volume. The higher degree of appraisal accuracy on SOAV timber sales reduces probability of under- or over-estimating volume. Brown et al. (2010) indicated that approximately two-thirds of public timber sale program administrators felt that SOAV sales require more time for presale measurement of stand volume. However, the cost savings associated with consumer-scale sales from reduced timber cruising time may not outweigh the additional cost of implementing a consumer-scale ticketing system (Deckard et al., 2011).

Leffler and Rucker (1991) discussed the financial tradeoffs of different timber payment methods through a transaction cost framework. They found the consumer-scale method should be implemented when the seller has relatively high presale measurement costs and low harvest monitoring costs. The seller's presale measurement cost is the time spent timber cruising. Monitoring costs are the costs of enforcing harvesting practices and enforcing and tracking timber removals from the harvest site. Presale measurement costs might depend on the timber payment method. Since the SOAV timber payment method does not require the buyer to track the harvested timber volume, transaction costs for monitoring will be lower compared to consumer-scale sales. However, the reduced timber monitoring costs under the SOAV method might be offset by the increased cost of estimating presale timber volume. Consequently, a high degree of uncertainty remains regarding the optimal timber payment method as it relates to presale measurement and monitoring systems due to the lack of information on and analysis of the actual transaction costs for those activities.

Financial Risk

Leffler and Rucker (1991) also discussed risk-based models in their timber payment method choice criteria. Influenced by the optimal risk sharing models developed by Leland (1978), the authors contended that SOAV timber sales lead to more intensive presale measurement on the part of buyers and sellers, thereby reducing the total risk borne by both parties. However, a potential shortcoming of the SOAV timber payment method is that the financial risk largely shifts to the buyer (i.e., any volume underruns result in a financial loss to the buyer). In fact, Brown et al. (2010) documented state timber sale supervisor sentiment that buyers often prefer the consumer-scale method because they would not have to incur as much risk when bidding for a tract. In practice, many stumpage buyers do not have the time or resources to conduct their own presale estimates of merchantable timber volume on each tract, so they cannot verify the appraisal accuracy and must bear the risk of an underrun on an SOAV tract (Blinn and Kilgore, 2005). Bidders can mitigate the risk of a volume underrun on an SOAV tract by discounting their stumpage bid prices, which results in a decrease in gross timber sale receipts for the seller.

Agriculture research addressed similar questions regarding the financial risk under different contractual arrangements for farmers. Similar to the timber payment methods, farmers primarily lease land from landowners using cash lease (similar to SOAV) or a crop share contract (similar to consumer scale). According to Edwards and Hart (2013), over the last several decades, farm leases in the northern U.S. have been moving toward cash leases instead of crop share contract, which has resulted in a significant transfer of risk to the lessee. Renters with farmland cash leases incur the risk of uncertain future crop yields, which is similar to the SOAV timber payment method, whereby the lessees purchase tracts based on estimated volumes and incur the risk of a volume underrun. In a crop share contract, the lessee pays the landowner an amount based on the crop yield, which is similar to a consumer-scale timber sale contract. Barry et al. (2002) suggested that risk avoidance is one of the major factors of farmland owners' preference for cash leases, which highlights the ultimate leverage land owners have over renters. Risk minimization is also a major factor that leads timberland managers to utilize SOAV sales. Conversely, many lessees (e.g., farmers who lease land or timber buyers) tend to prefer to pay by unit (e.g., crop share or consumer scale) to minimize their overall risk; however, the landowner ultimately controls the type of payment method that is offered.

Public Timber Sale Programs in Minnesota
The policies and procedures used by Minnesota public timber sales program are informed by laws, administrative codes, and agency guidelines. The management of federal forest land is primarily guided by the Multiple-Use Sustained Yield Act of 1960 (Brown et al., 2010), which states that "national forests are administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (16 U.S. Code 528). The federal policy largely focuses on "net public benefits" and does not explicitly state a fiduciary responsibility.

The MN DNR manages approximately 4.2 million acres of forest land, the largest proportion of which (2.47 million acres) is school trust land, which requires managers to maximize long-term economic return and maintain conservation principles (Office of Legislative Editor, 2014). The revenue generated on school trust lands directly supports the state's K-12 education system. State-owned lands were originally granted by the federal government to fund the state's educational system (Brown et al., 2010). Similar to federal forest management, the Minnesota DNR manages forests based on multiple use[14] and sustained yield principles.[15]

Minnesota's 2.56 million acres of county-administered forest land represents the largest county administration of forest land of any state (Minnesota Department of Natural Resources: Resource Assessment, 2014). The county-administered forests in Minnesota are lands that reverted from private to public ownership due to nonpayment of taxes. The state holds the title to these tax-forfeited forest lands in trust for the local taxing districts. However, Minnesota law provides that land forfeited to the state for nonpayment of taxes and classified as conservation lands are under the management authority of county boards. Minnesota counties with substantial holdings of these tax-forfeited forest lands have, in turn, established land departments to facilitate the management of these forests for timber and non-timber benefits (MACLC, 2011). Table 1 illustrates the number of acres of forest land managed by county governments in Minnesota. County land departments independently manage timber assets and have created separate management policies to oversee their timber assets. Citizen advisory committees are often established to provide input and perspective to county forestry staff about forest land management policies and objectives. Net proceeds from county timber sales support local public schools, reinvestment in land administration, township governments, and other county activities (Baughman, 1983).

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[14] **Multiple use** is the principle of forest management by which forest resources are utilized in the combinations (e.g., revenue generation, recreation, wildlife habitat conservation, etc.) that will best meet the needs of the people of the state (*Minnesota Statutes 2013 89.001, subd. 9.*).

[15] **Sustained yield** is the principle of forest management that maintains high level of annual output of forest resources without impairment of the land's productivity (*Minnesota Statutes 2013 89.001, subd. 10.*).

Table 1. 1990 Minnesota County administered timberland.

Minnesota County	Acres managed (*thousands*)[1]
Aitkin	196.3
Becker	87.6
Beltrami	138.6
Carlton	58.0
Cass	232.9
Clearwater	66.8
Cook	9.2
Crow Wing	89.6
Hubbard	121.2
Itasca	255.7
Koochiching	278.8
Lake	143.6
Lake of the Woods	3.1
Pine	32.3
St. Louis	744.8
Total	**2,459**

[1] *Source*: Leatherberry et al., 1995.

1.3. Study Objective

The objective of this study is to assess how timber payment method impacts the cost-effectiveness of timber sale programs administered by the SLCLD. To accomplish this objective, the study assesses the differences in total administrative costs and gross timber sale revenue to explain the financial tradeoffs associated with each timber payment method. It is hypothesized that the SOAV timber payment method increases gross timber sale revenue due to the buyer's ability to merchandize more volume compared to the consumer-scale payment method. It is also posited that the additional cost of administering the ticketing process for the consumer-scale payment method and the additional cost of timber cruising for the SOAV payment method creates differences in the total administrative costs.

Study Area

The study was conducted using data provided by the SLCLD. St. Louis County is the largest county in Minnesota (Figure 2), managing approximately 872,100 acres of forest land of which 639,400 acres are considered commercial forest land (St. Louis County Minnesota, 2015). The primary reasons behind selecting SLCLD for this study are the relatively high number of annual timber sales, the physical characteristics of SLCLD timber sales (i.e., species, volume, and location), the agency's use of both timber payment methods, and their willingness to collaborate on the study. The SLCLD conducts four timber auctions annually (i.e., one per quarter), selling the harvest rights to approximately 80 to 120 timber tracts. In addition, the SLCLD sells timber stumpage on approximately 10,000 acres (i.e., 200,000 cords) annually, which support local buyers, wood products companies, and many other related industries (St. Louis County Minnesota, 2015). The SLCLD employs 62 individuals, who perform all the duties that pertain to managing the SLCLD forest land and mineral assets (Blinn, 2014).
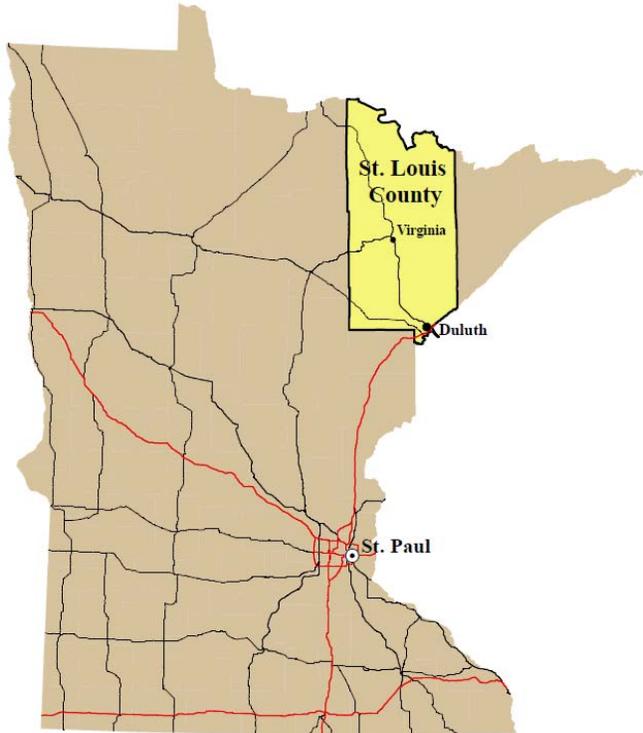
Figure 2. St. Louis County, Minnesota.

The diversity of forest types in SLCLD is wide ranging. The major tree species include: aspen, birch, ash, balsam fir, spruce, tamarack, white/red/jack pine, and maple (Appendix B), which provide a variety of end-products (i.e., primarily pulpwood and pulp and bolts). The tree species contained in SLCLD's timber sales are representative of the forest types found within the county. Aspen species are the most prevalent species sold by the SLCLD, accounting for approximately 45% of the total annual volume sold (Appendix B).

The SLCLD utilizes both timber payment methods. Both timber payment methods are regularly implemented by the SLCLD. From 2006 to 2012, the SLCLD utilized the SOAV timber payment method for approximately 37% of all appraised volume sold and the consumer-scale timber payment method for 63% of appraised volume sold. The SLCLD employs all three combinations of the two timber payment method, which include selling tracts with 100% consumer scale, 100% SOAV, and blended sales.

Report Organization
Figure 3 illustrates how the two timber payment methods are examined within this report using data collected from the SLCLD.
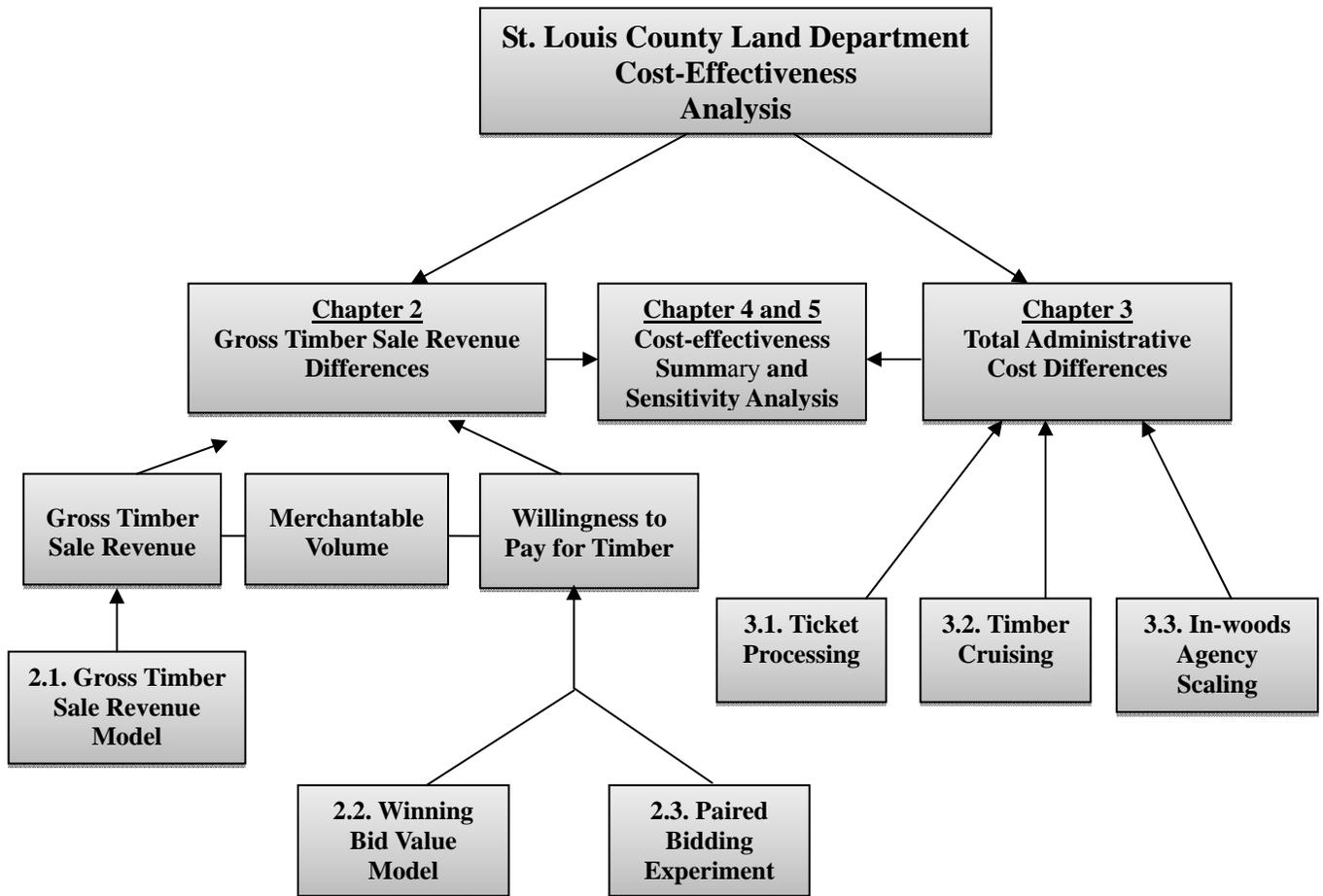
Figure 3. Overview of the cost-effectiveness analysis.

The analysis is split into four chapters, which evaluate the differences of gross timber sale revenue and agency timber sale administrative costs. Chapter 2 contains a two-part analysis that investigates whether the selection of timber payment method impacts SLCLD's gross timber sale revenue. Chapter 3 estimates the total administrative cost differences between the two timber payment methods. Chapter 4 presents a summary of SLCLD's net timber sale revenue associated with the consumer-scale and SOAV timber payment methods. Chapter 5 uses the analyses from Chapters 2, 3, and 4 to estimate net timber sale revenue differences between the two timber payment methods under a range of assumptions.

The following describes how the analyses are presented in this report.

Chapter 2: This chapter focuses on timber payment method's influence on the components that drive gross timber sale revenue. The components of gross timber sale revenue are WTP for timber and merchantable volume. The analysis investigates whether timber payment method causes differences in either component of gross timber sale revenue. Through hedonic price

analyses[16] and a technique called the paired bidding method, the gross timber sale revenue and WTP differences are approximated and differences in the utilization of merchantable volume are deduced. Section 2.1 investigates the gross timber sale revenue differences, while sections 2.2 and 2.3 evaluate the WTP differences.

The first hedonic price model is the gross timber sale revenue model (section 2.1), which evaluates the impact of several timber sale characteristics on gross timber sale revenue per acre. This section utilizes data from the SLCLD to create a multivariate regression model to assess whether the degree to which timber payment method impacts gross timber sale revenue. However, the gross timber sale revenue model is not able to determine whether WTP for timber and/or utilization of merchantable volume are the driving force behind timber payment method's influence on gross timber sale revenue. Therefore, a second hedonic price model and a paired bidding experiment evaluates whether timber payment method impacts a bidder's WTP.

The second hedonic price model, winning bid value model (section 2.2), evaluates timber payment method's influence on a bidder's WTP. Since public timber is sold through an auction process, WTP was the buyer's unit bid price for each species-product combination. The winning bid value model utilizes the same SLCLD timber sale data as the gross timber sale revenue model, but the dependent variable represents the differences in WTP attributed to the timber payment method.

The influence of the timber payment method on WTP is also explored through a field experiment called paired bidding (section 2.3). Paired bidding assesses the impact of different timber sale attributes on a bidder's WTP for a tract of timberland. The technique requires a given tract of timber to be advertised for sale (via a sealed bid auction) in two ways, wherein the only difference between the two versions is the variable of interest—timber payment method.

The differences in utilization of merchantable volume are analyzed indirectly through the findings of the gross timber sale revenue model (section 2.1) and the two analyses on WTP for timber (sections 2.2 and 2.3). Due to data constraints, the differences in merchantable volume were not directly assessed. To directly evaluate utilization, public agencies would need to collect data on the volume removed for both SOAV and consumer-scale sales. The SOAV timber payment method does not require the buyer to report the total volume harvested; therefore, SOAV sales only have information on appraised volume and not on scaled volume. The merchantable volume component is evaluated by examining two of the three terms (i.e., gross timber sale revenue and WTP for timber) in the gross timber sale revenue equation: gross timber sale revenue = WTP for timber (unit bid price by species-product combination) x merchantable volume.

Chapter 3: This chapter analyzes the administrative cost differences between SOAV and consumer-scale timber payment methods. While many of the administrative processes are similar for the two timber payment methods, there are operational features that distinguish one system from the other. These distinctive operational aspects create differences in the overall cost structure; the features that are unique to each timber payment method are analyzed and the cost differences are measured. The major cost differences between timber payment methods are the

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[16] According to Griliches (1991) hedonic price analysis "relates the prices of different versions of a commodity to differences in their characteristics, qualities, and discovers thereby the relative valuation of such qualities."

administrative resources spent on the timber cruising, consumer-scale ticketing system, and in-woods agency scaling.

The costs of timber cruising (section 3.1) are analyzed based on information provided by the SLCLD. SOAV sales often require more time spent appraising to reduce the likelihood of volume estimation errors. The SLCLD does not differentiate timber cruising time between timber payment methods (Jason Meyer of SLCLD, personal communication, 2014); therefore, there is no marginal timber cruising cost difference between timber payment methods for that agency.

In order to estimate the administrative costs associated with the consumer-scale ticketing process, the time spent on various consumer-scale ticketing tasks was collected from the SLCLD office personnel responsible for administering and processing timber sale tickets (section 3.2). The time study required SLCLD administrators to record the minutes they spent on each of the five stages of the ticketing process. The time attributed to each administrative task was evaluated to measure the estimated average cost of the ticketing process per sale. The total administrative time was converted into a cost based on the approximate hourly wage (plus benefits) of personnel who performed these tasks.

The cost of in-woods agency scaling is calculated based on the estimated annual time the SLCLD spent manually scaling each cord that was not destined to be delivered to a mill with a consumer scaling agreement with the SLCLD. The majority of consumer-scale volume sold by the SLCLD is scaled by consuming mills; however, agency scale information was gathered from SLCLD to account for the cost of scaling harvested timber that was not destined for a consuming mill (e.g., firewood sold to a private landowner). The time estimate for in-woods agency scaling is converted into a cost based on the approximate hourly wage (plus benefits) of foresters.

Chapter 4: This chapter provides a summary of the net timber sale revenue to the SLCLD timber sale program that is associated with the SOAV and consumer-scale payment methods. It combines the results from the gross timber sale revenue and total administrative cost analyses conducted in Chapters 2 and 3 to estimate average cost differences per sale between the two timber payment methods.

Chapter 5: This chapter presents a sensitivity analysis to assess the impact of hypothetical cost scenarios associated with the timber payment methods. Payment methods vary widely among timber sale programs in their implementation and efficiency; therefore, the summary of the SLCLD timber sale program in Chapter 4 is utilized to develop estimates of agency costs under a range of cost assumptions. Since the SLCLD does not differentiate the administrative time spent timber cruising between timber payment methods (i.e., zero cost differences), but other timber programs do utilize distinct timber cruising standards, Chapter 5 also estimates the cost of timber cruising an average timber sale in the SLCLD to evaluate the total cost difference between payment methods in other timber sale program cost scenarios.

The exploration of different administrative cost scenarios in Chapter 5 forms the basis for the sensitivity analysis. Hermeling and Mennel (2008) defined sensitivity analysis as how the variation in the output of a model can be apportioned to different sources of variation in input parameters. In the sensitivity analysis, four distinct cost scenarios are developed based on the SLCLD's timber program's costs to assess the impact of changes in a timber program's

procedures (e.g., timber appraisal standards) and a payment method's cost efficiency (e.g., higher and lower cost consumer-scale ticketing process). These cost scenarios are used to illustrate how the total cost per timber sale changes under different assumptions regarding the cost of administering timber payment methods. The four scenarios include a different timber cruising standards scenario (higher cost for SOAV timber cruising), a high cost consumer-scale scenario (higher cost ticketing system), a low cost consumer-scale scenario (low cost ticketing system), and a MN DNR scenario (higher cost for SOAV timber cruising and ticketing cost for SOAV sales). The findings in the sensitivity analysis are beneficial to understanding the influence of different cost scenarios related to timber payment method in other public timber programs.

Chapter 6: This chapter presents a summary and conclusion of the cost-effectiveness assessment. In addition, the study's results are compared to the previous literature on timber payment method. Lastly, this section provides potential ways to enhance a timber program's use of timber payment method.

To summarize, the key questions to be addressed in this study are:

1) How does the selection of timber payment method impact gross timber sale receipts? (Chapter 2)

2) How does the timber payment method influence WTP for timber and utilization of merchantable volume? (Chapter 2)

3) What are the administrative cost differences between timber payment methods? (Chapter 3)

4) How does selection of timber payment method impact the cost-effectiveness of the SLCLD timber program? (Chapter 4)

5) How might selection of timber payment method impact the cost-effectiveness of other timber programs? (Chapter 5)

2. Assessment of Gross Timber Sale Revenue Differences

A key aspect of public timber sale programs is to understand the factors that drive gross timber sale revenue—the total revenue received before any expenses are deducted. The two components of gross timber sale revenue considered in this analysis are the WTP for timber and merchantable volume. WTP is the unit bid price for each tree species-product combination and merchantable volume is the scaled (consumer-scale) or appraised (SOAV) amount of timber. The key questions addressed in this chapter are how timber payment method influences the two components of gross timber sale revenue. To assess those potential revenue differences between SOAV and consumer-scale timber payment methods, hedonic price methods and an experimental technique called paired bidding are employed.

Background
Hedonic price analyses are a common method for analyzing timber sale data and are often employed by forest economists to better understand the factors that influence stumpage price. Griliches (1991) noted that the hedonic method "relates the prices of different versions of a

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commodity to differences in their characteristics, 'qualities,' and discovers thereby the relative valuation of such qualities" (p. 185). In other words, hedonic methods model a price function to estimate the relationship between the price of a good, input, or service and the characteristics embodied within that good, input, or service (Brown et al., 2012). This study utilized hedonic price analysis to assess the significant predictors of gross timber sale revenue from timber sales offered by the SLCLD.

Brown et al. (2012) reported that there are a number of timber sale characteristics that influence WTP for public timber including: physical characteristics, tract location, product markets, and administrative procedures. MacKay and Baughman (1996) found that the physical factors that influence Minnesota stumpage prices include species composition and volume density. Tract location was reported to be a significant predictor of stumpage prices in Buongiorno and Young (1984), MacKay and Baughman (1996), Carter and Newman (1998), Niquidet and van Kooten (2006), and Brown et al. (2012). These studies indicate that tract location and longer distance to the consuming mill lowered stumpage prices. Brown et al. (2012) also reported that the mix of timber products (e.g., sawtimber, pulpwood) impact stumpage prices, as the demand of specific timber products is heavily influenced by the prices for their end product markets (e.g., housing market, paper). The administrative procedures that have been found to influence stumpage prices include contract length (Munn and Rucker, 1995; Leefers and Potter-Witter, 2006; Brown et al., 2012), quarter of the year during which a public timber sale is offered for sale (Leefers and Potter-Witter, 2006), harvest restrictions (MacKay and Baughman, 1996; Brown et al., 2012), and timber sale auction method (Johnson, 1979; Wiener, 1979). No empirical studies have reported an assessment of how timber payment method influences gross timber sale revenue or WTP for timber.

The two hedonic price models used in this study are the gross timber sale revenue model (section 2.1.) and the winning bid value model (section 2.2). The gross timber sale revenue model investigates the influence of timber payment method and several timber sale characteristics on gross timber sale revenue. The winning bid value model analyzes the impact of timber payment method and several timber sale characteristics on the bidder's WTP for timber.

Information on volume harvested and sold to a consumer was not available for the SOAV portion of SLCLD timber sales because the volume harvested and sold under the SOAV timber payment method was not recorded by the SLCLD. Most public agencies in Minnesota only collect scaled volume information for timber which is sold under the consumer-scale payment method. The SOAV timber payment method does not require the buyer to report the volume removed from a harvest site, so SOAV sales only have information on estimated (appraised) volume. The MN DNR recently instituted an SOAV ticketing system in response to a forest certification requirement, which served as an initial approach for collecting volume information for SOAV sales. However, the MN DNR's scaled volume data did not include complete records of all volume harvested on SOAV sales. No other public agencies in Minnesota were found to have information on scaled volumes for both timber payment methods. Since the scaled volume data for both timber payment methods was unavailable, the merchantable volume differences are derived by calculating the terms, gross timber sale revenue and WTP for timber, and the merchantable volume term is derived (Equation 1).

Equation 1. Gross timber sale revenue = WTP for timber x merchantable volume[17]

The paired bidding technique also evaluates the WTP for timber term in Equation 1. The paired bidding method is a field experiment applied to public timber sales in which a tract of timber is offered for sale in two ways, with only the variable of interest varying between the two sale offerings (Kilgore and Blinn 2003). Paired bidding strictly controls for all timber sale factors influencing price (both observed and unobserved), except the variable of interest (Kilgore and Blinn, 2003). The variable of interest in this study is the timber payment method, with one tract offered as SOAV and the other consumer scale. Kilgore and Blinn (2003) first utilized paired bidding experiments to investigate the impact of harvesting guidelines on a bidder's WTP, and Brown et al. (2013) later used the technique to explore the influence of contract length and reserve prices on WTP. The experiment for timber payment method is conducted on SLCLD timber sales, and the results provide an additional means by which to analyze the impact of timber payment method on a bidder's WTP for timber.

Data and Methods
The two hedonic price models, the gross timber sale revenue model and the winning bid value model, use the same SLCLD timber sale dataset. An Excel database containing 592 SLCLD timber sales closed between January 1, 2004, and December 31, 2013 was obtained from the SLCLD staff. A closed timber sale is a tract that has been fully harvested, and the buyer has met all contractual obligations for that sale (e.g., harvesting guidelines, silivicultural requirements, appropriate level of utilization). The database contained information on permit number, total revenue received from the buyer, total winning bid value, total appraised volume by species, auction date, closing date, location of tract (North [Pike Lake Area Office] or South [Virginia Area Office] area within the county), sale acres, auction method (oral or sealed bid), timber payment method by species (SOAV or consumer scale), and number of harvesting blocks[18]. Additional information for the analysis (e.g., season of harvest) was also gathered from a review of timber sale auction listing and merged with the Excel dataset. An initial inspection of the data revealed that several tracts were sold as noncompetitive timber tracts (i.e., informal timber sales without going through a public auction process), some were salvage sales (e.g., stands of timber damaged by fire, disease, or infestation), and some tracts were missing relevant data for the variables of interest. These tracts were removed from the final sample, and the remaining 473 tracts of timber sold between January 1, 2006, and December 31, 2012, were used in the analyses.

Separate models are developed to predict gross timber sale revenue per acre (section 2.1) and the winning bid value per acre (section 2.2). Multivariate regression analyses are employed for both models using SAS 9.3 (SAS Institute Inc.). The gross timber sale revenue model analyzes timber payment method's influence on gross timber sale revenue, while the winning bid value model evaluates timber payment method's influence on WTP for timber. The two models use the same independent variables in the analyses, which included the timber payment method, species composition (i.e., percent aspen, hardwood, and softwood species), volume density (i.e., appraised cords per acre), season of harvest (i.e., only operable during the winter or operable

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[17] Merchantable volume in Equation 1 is different for each payment method. SOAV sale's merchantable volume is the appraised volume, and consumer scale sale's merchantable volume is the scaled volume.
[18] **Harvesting blocks** are the discrete parcels that are a part of a single sale. Timber sales can have multiple harvesting blocks, which can be adjacent to other sale blocks or separated.

during the winter and at other times during the year), quarter and year of the auction, location of the tract (i.e., north or south SLCLD area), number of harvesting blocks, and auction type (i.e., oral or sealed bid).

The second empirical technique, the paired bidding experiment, analyzes how timber payment method influences a bidder's WTP (section 2.3). The paired bidding experiment for timber payment method was implemented on February 20, 2014, and was administered by the SLCLD staff through a sealed bid auction process. The SLCLD offered 16 tracts for sale for the paired bidding experiment, which resulted in 84 paired bids for 15 tracts which actually received bids. The differences between each set of paired bidding values are evaluated to understand whether bidders differentiate stumpage bids based on the timber payment method.

2.1. Gross Timber Sale Revenue Model

The gross timber sale revenue model investigates the influence of the timber payment method on gross timber sale revenue per acre. The model utilizes several timber sale characteristics to estimate gross timber sale revenue, including a timber payment method variable. The primary focus of this model is the interaction between timber payment method and the dependent variable, gross timber sale revenue per acre. The gross timber sale revenue for timber sales on 100% consumer-scale sales is the product of the harvested and scaled volume multiplied by the winning bid price for each species-product combination. The gross timber sale revenue on 100% SOAV timber sales equals the estimated merchantable timber volume multiplied by the unit winning bid price for each species-product combination. The gross timber sale revenue from blended sales, wherein a portion of the tract volume is sold using the SOAV method and a portion is sold using consumer-scale method, equals the estimated merchantable volume reported on the timber sale auction listing multiplied by the unit winning bid value for the SOAV portion plus the harvested volume multiplied by unit winning bid price for the sale's consumer-scale portion. Therefore, the gross timber sale revenue per acre differences between SOAV and consumer-scale sales are a function of the differences in the estimated and scaled volumes or the differences in unit winning bid price for each species-product combination (i.e., WTP), holding all other factors constant (Table 2).

Table 2. Overview of how gross timber sale revenue is determined for each timber payment method.

Timber payment method	Merchantable volume		Willingness to pay		Gross timber sale revenue differences
SOAV	estimated (appraised) volume from the timber sale auction listing	x	winning unit bid price by species-product composition	=	gross timber sale revenue (per acre)
Consumer scale	scaled volume	x	winning unit bid price by species-product composition	=	gross timber sale revenue (per acre)

Prior to advertising a timber sale, a forester walks through the sale area to estimate the volume of merchantable timber. Differences can occur between estimated stand volume and actual scaled volume. Deckard et al. (2011) reported that the difference between the estimated and scaled volumes on 846 MN DNR consumer-scale sales varied widely. The authors indicated that 62% (521 sales) had scaled volumes within ±20% of the estimated volume, 25% (213 sales) scaled

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more than 120% of the estimated volume, and 13% (112 sales) scaled less than 80% of the estimated volume.

This study posits that the variation between scaled and estimated volumes is attributed to the following four elements: (1) errors by timber sale appraisers, (2) strength of market conditions at the time of harvest, (3) changes in stand volume (e.g., stand growth or mortality) between the time when the volume was appraised and when the stand was harvested (i.e., timber sales generally allow three years for harvesting to occur), and (4) distance to market. Errors by timber sale appraisers can result during field work (e.g., incorrectly estimating diameter or height, unobserved rot or decay), and buyers might harvest more (overestimated volume) or less (underestimated volume) volume than what was appraised due to these errors. The strength of market conditions and markets available to the buyer at the time of harvest might impact the utilization of a tract (better markets for the products resulting in a higher rate of utilization). Changes in stand volume include volume growth (i.e., changes in estimated merchantable stand volume between timber appraisal and final harvest) and/or a loss of merchantable volume due to catastrophic events (e.g., fire, disease, or blowdown). Distance to market might also impact the variation between scaled and estimated volumes, as buyers might utilize less wood if the transportation costs are too high (i.e., longer distances to end market).

The null hypothesis for this analysis is that there are no differences in gross timber sale revenue attributed to the timber payment method. As discussed in section 1.2, the SOAV timber payment method is theorized to create higher rates utilization of merchantable volume. Under the SOAV method the buyer may be incentivized to harvest volume that may not have been merchandized under the consumer-scale timber payment method because there are no associated stumpage costs once all of the appraised volume has been harvested and scaled (i.e., additional volume harvested beyond the appraised volume has a lower overall production cost than under the consumer-scale payment method). Therefore, the increased desire to harvest volume beyond the appraised amount on SOAV sales, with the lower overall production cost for that additional material, is theorized to result in higher WTP for timber sold under the SOAV payment method. The gross timber sale revenue model tests whether the timber payment method influences the SLCLD's gross timber sale revenue and then tests whether the timber payment method influences WTP for timber in sections 2.2 and 2.3.

It is also theorized that the forester that appraised the timber sale influences a bidder's WTP for timber, as many buyers become familiar with a forester's timber appraisal practices (e.g., tend to underestimate merchantable volume for one or more species) and use that information to adjust their WTP accordingly (Kilgore and Blinn, 2005). If knowledge about the forester's appraisal practices influences bidding behavior, then SOAV sales would be influenced in the same direction (e.g., appraiser A always underestimates volume on all timber sales, so buyers' WTP would be higher for SOAV sales). The appraiser's accuracy would be less likely to influence a buyer's WTP for consumer-scale sales because buyers have to pay per unit harvested and sold to a consumer. This study does not examine the influence individual timber appraisers have on a buyer's WTP for timber.

Model Specification
An ordinary least squares (OLS) regression model is used to model the 473 SLCLD timber sales. The hedonic price model used SAS 9.3 software to conduct the analysis. Since some key

variables that influence bidding behavior are not observable, such as the bidder's demand for a specific sale or individual logging skill, the OLS model only evaluates the influence of the observed characteristics (e.g., appraised volume, species composition, timber payment method) on the dependent variable (i.e., gross timber sale revenue per acre). Despite the OLS model's inability to control for all factors influencing gross timber sale revenue, it is useful for predicting the relative influence and significance of observed timber sale features on gross timber sale revenue. Several studies have used OLS regression to estimate the marginal effects of timber sale features on WTP for timber, including Jackson and McQuillan (1979), Buongiorno and Young (1984), Puttock et al. (1990), MacKay and Baughman (1996), Dunn and Dubois (2000), and Leefers and Potter-Witter (2006). Brown et al. (2013) also used OLS regression to create a hedonic price function for northern MN DNR timber sales.

The following expression is used to estimate the hedonic price function for the SLCLD timber sales:

$$\textit{Equation 2. } \text{Gross Timber Sale Revenue (\$/acre)} = \alpha_i + \sum \beta_j x_i + \varepsilon_i$$

The x_i's in Equation 2 are the tract characteristics that could influence the gross timber sale revenue per acre received by the SLCLD, and β_j's are the parameter estimates indicating the direction and relative strength of the relationship with respect to gross timber sale revenue per acre. The term α_i is the intercept parameter, and ε_i is the error term.

Brown et al. (2010) used the natural log form to interpret stumpage prices (dependent variable) as semi-elasticities, which predicted that a one unit change in a coefficient had a (β_j*100) % change on stumpage prices. However, none of the model variables were transformed here as model diagnostics log transformations does little to improve model fit. A Box-Cox plot is used to test the normality of the linear model, and the results indicate that no transformation is necessary. In addition, the plot of residual and predicted values shows no trend in the error term, indicating that the linear model is an appropriate functional form.

The timber tract characteristics included in the gross timber sale revenue model and their hypothesized impact (i.e., positive or negative impact on gross timber sale revenue per acre) on gross timber sale revenue per acre are shown in Table 3. The independent variables include timber payment method (SOAV), species composition (percent aspen, hardwood, and softwood species), volume density (appraised cords per acre), season of harvest (winter), quarter and year of the auction, location of tract (north or south SLCLD area), number of harvesting blocks, and auction type (oral or sealed bid). A Pearson Correlation Coefficient (PCC) test performed to measure the linear correlation between all of the independent variables found that the percent softwood variable had a high negative correlation with the percent aspen (-0.61) and percent hardwood (-0.52) variables and is omitted from the final model.

Table 3. Description of timber tract characteristics from the SLCLD database and their expected impact on gross timber sale revenue per acre.

Timber tract characteristic	Description	Expected impact on gross timber sale revenue per acre[1]
SOAV	The percent (0 to 100) of the total appraised volume sold under the SOAV timber payment method. The remainder was the portion sold under the Consumer-scale (CS) method.	(+) higher utilization on SOAV sales
Hardwood	The percent (0 to 100) of total appraised volume that was comprised of hardwood species. Calculated by dividing total hardwood cords appraised by total cords appraised within the tract.	(-) hardwood species are lower value species
Softwood	The percent (0 to 100) of total appraised volume that was comprised of softwood species. Calculated by dividing the total softwood cords appraised by total cords appraised within the tract.	(+) softwood species are often higher value
Aspen	The percent (0 to 100) of total appraised volume that was comprised of aspen species. Calculated by dividing the total aspen cords appraised by total cords appraised within the tract.	(+) aspen is a higher value species
Appraised cords per acre	The total estimated (appraised) volume in cords per acre. Calculated by dividing total estimated cords appraised by total acres.	(+) higher density of harvestable volume per unit area
Location	Binary variable that equals one if the tract was administered through the southern area office (Pike Lake) in St. Louis County; variable equals zero if the tract was administered through the northern area office (Virginia) in St. Louis County.	(+) southern area is closer to more consuming mills
Sealed bid	Binary variable that equals one if the tract was offered for sale through a sealed bid auction; equals zero if the tract was offered for sale through an oral auction.	(+) sealed bid known to increase WTP
Blocks	Number of sale parcels (i.e., blocks) per tract. Includes sales with up to 9 blocks (87.1% of sales had fewer than 4 blocks).	(-) higher move costs for each additional harvesting block
Winter	Binary variable that indicates that the buyer may only harvest the sale during frozen ground conditions, as identified on the timber sale auction listing. The variable equals zero if the tract was only accessible during the summer or if there were no seasonal restrictions placed on when the tract could be harvested. 1 =winter only and 0 = summer or year-round.	(-) winter only harvesting restriction reduces bidders' WTP because more tracts are offered for sale with this restriction
Quarter [1-4]	Four dummy variables that indicate the quarter during which the sale sold (i.e., auction date). Q1=January-March; Q2=April-June; Q3=July-September; Q4=October-December. Q4 was omitted, as the base comparison.	(+) higher seasonal need for timber sales in beginning of calendar year[2]
Year [2006-2012]	Six dummy variables used to indicate the calendar year in which the sale was offered (Year06-Year12). Year06 was omitted, as the base comparison.	(-) lower timber prices in years 2007-2012

[1]Positive and negative expected influence on gross timber sale revenue per acre are noted by (+) and (-), respectively.

[2] Quarter variable's hypothesis is based on findings in Brown et al. (2012).

Table 4 presents descriptive statistics for the continuous variables included in the gross timber sale revenue model. The SLCLD dataset includes a wide variety of tract sizes, ranging from 2.5 to 384 acres. The median and average estimated cords per acre were 22.4 and 22.1 acres, respectively. SLCLD sold approximately 37% of appraised volume through the SOAV payment method. In addition, a diversity of species mixes was present within the data, which is consistent with the forest types seen across the St. Louis County landscape. Table 5 lists the frequency of occurrence for the independent variables in the SLCLD dataset.

Table 4. Descriptive statistics from the SLCLD database for the continuous variables included in the gross timber sale revenue model (n=473).

Variable Name	Definition	Mean	Median	Min	Max
Gross timber sale revenue per acre[1]	Total sale revenue divided by total sale acres	$520.95	$481.67	$23.26	$2,604.24
SOAV	Percent of total appraised volume that was sold through the SOAV timber payment method	37.2%	18.3%	0.0%	100.0%
Hardwood	Percent of total appraised volume that was comprised of hardwood species, includes: ash (green and black), basswood, birch (yellow and paper), maple (red and sugar), oak (burr and red), and elm	22.0%	15.1%	0.0%	100.0%
Aspen	Percent of total appraised volume that was comprised of aspen, includes: bigtooth aspen, quaking aspen, and balm of gilead	45.8%	47.0%	0.0%	98.1%
Appraised cords per acre	Total appraised cords divided by total sale acres	22.4	22.1	4.8	68.8

[1]Gross timber sale revenue per acre was the dependent variable.

Gross Timber Sale Revenue per Acre (Dependent Variable)
The dependent variable in the gross timber sale revenue model is the gross timber sale revenue per acre. As illustrated in Table 2, the calculation of gross timber sale revenue varies by timber payment method. SOAV gross timber sale revenue is based on estimated volumes as reported in the timber sale auction listing multiplied by the winning bid price for each species-product combination, while consumer-scale gross timber sale revenue is based on scaled volume and the winning bid price for each species-product combination. Gross timber sale revenue on blended sales is calculated based on what was scaled for the consumer-scale volume and what was estimated for the SOAV volume. As the SLCLD dataset only includes the actual gross timber sale revenue received per sale, the dependent variable is calculated using gross timber sale revenue divided by total acres.

Timber Payment Method (SOAV)
The timber payment method variable (i.e., SOAV) is the primary variable of interest in this study. The SOAV variable is calculated by taking the total appraised volume sold with the SOAV timber payment method divided by the total appraised volume in cords for the timber sale (i.e., the sum of both SOAV and consumer-scale volume). The SLCLD allows foresters to use either timber payment method for each specie on a given timber sale; therefore, blended sales have volume sold with SOAV and volume sold with consumer scale. The SOAV variable is a proportion bound between 0.0 and 1.0 that represents the volume sold with the SOAV timber payment method. The majority of SLCLD timber sales are blended sales. Similar to the species composition variables, the SOAV variable is interpreted as the change in gross timber sale revenue per acre as the SOAV variable changes one unit (i.e., 0.0 to 1.0). A one unit change in

the SOAV variable is going from 0.0 (i.e., 100% consumer scale) to 1.0 (100% SOAV). A plot of the distribution of timber payment method against gross timber sale revenue per acre (i.e., dependent variable) does not appear to have any trend in the data (Figure 4).

Independent variable	% of sales
SOAV	37.2%
Hardwood	22.0%
Aspen	45.8%
South location	52.2%
Sealed bid	55.6%
One block	32.6%
Two blocks	33.8%
Three blocks	20.7%
Four blocks	9.7%
Five blocks or more	3.2%
Q1[1]	21.78%
Q2	30.7%
Q3	25.2%
Q4	22.4%
Year06[2]	4.4%
Year07	23.7%
Year08	22.2%
Year09	17.1%
Year10	13.7%
Year11	12.7%
Year12	6.1%
Winter only	56.0%

[1]Quarter during which the sale occurred. Q1=January-March; Q2=April-June; Q3=July-September; Q4=October-December
[2]Calendar year during which the sale was sold.

Species Composition (Aspen and Hardwood)

From the Excel database for the 473 timber sales, 22 different species were identified which are grouped into three broad species categories: hardwood, softwood, and aspen. The hardwood category contains ash (green and black), basswood, birch (yellow and paper), maple (red and sugar), oak (burr and red), and elm. The softwood category is comprised of balsam fir, white cedar, mixed spruce, jack pine, Norway pine, white pine, black spruce, white spruce, and tamarack. The aspen category includes bigtooth aspen, quaking aspen, and balm of Gilead. For each species category, a percent of total estimated volume is calculated based on the appraised volumes by species group (e.g., 100 cords of aspen on a 200 cord sale equals 50% aspen). The composition variables measure the change in gross timber sale revenue per acre when the species category changes one unit (i.e., 0.0 to 1.0). For example, a one unit change in the hardwood variable is going from 0.0 (i.e., 100% consumer scale) to 1.0 (100% SOAV).
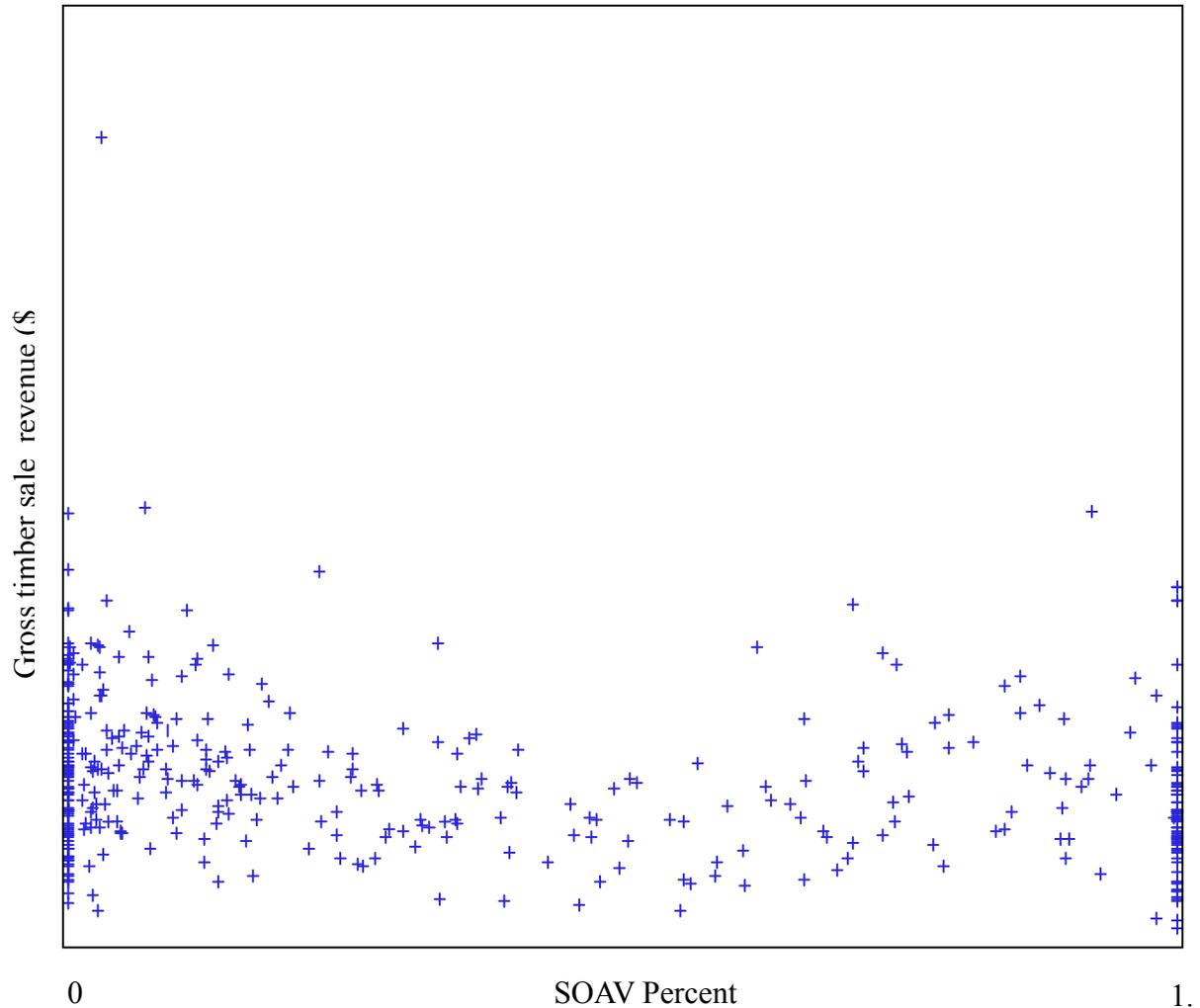
Figure 4. Plot of gross timber sale revenue per acre against the percent of total volume offered for sale under the SOAV timber payment method within each tract that closed within the SLCLD between 2006 – 2012. Observations with a value of 0.0 on the x-axis are 100% consumer scale and those with a value of 1.0 on the x-axis are 100% SOAV. Observations between 0.0 and 1.0 are mixed sales with a corresponding percentage of the volume sold as SOAV or consumer scale (n = 473).

The species compositions variables are utilized to explain how a change in species composition influences gross timber sale revenue per acre. MacKay and Baughman (1996) found that species-product composition was a significant predictor of stumpage price. Based on SLCLD's historic stumpage prices and previous stumpage literature (Mackay and Baughman, 1996), it is hypothesized that species composition are a significant predictor of gross timber sale revenue per acre. Between 2006-2012, there was a stumpage price premium for aspen and softwood species in SLCLD timber sales as compared to hardwood species, as shown in Figure 5. The relative price differences between species categories (Figure 5) form the rationale behind the expected influence of aspen, softwood, and hardwood species on gross timber sale revenue per acre (Table 3).

26
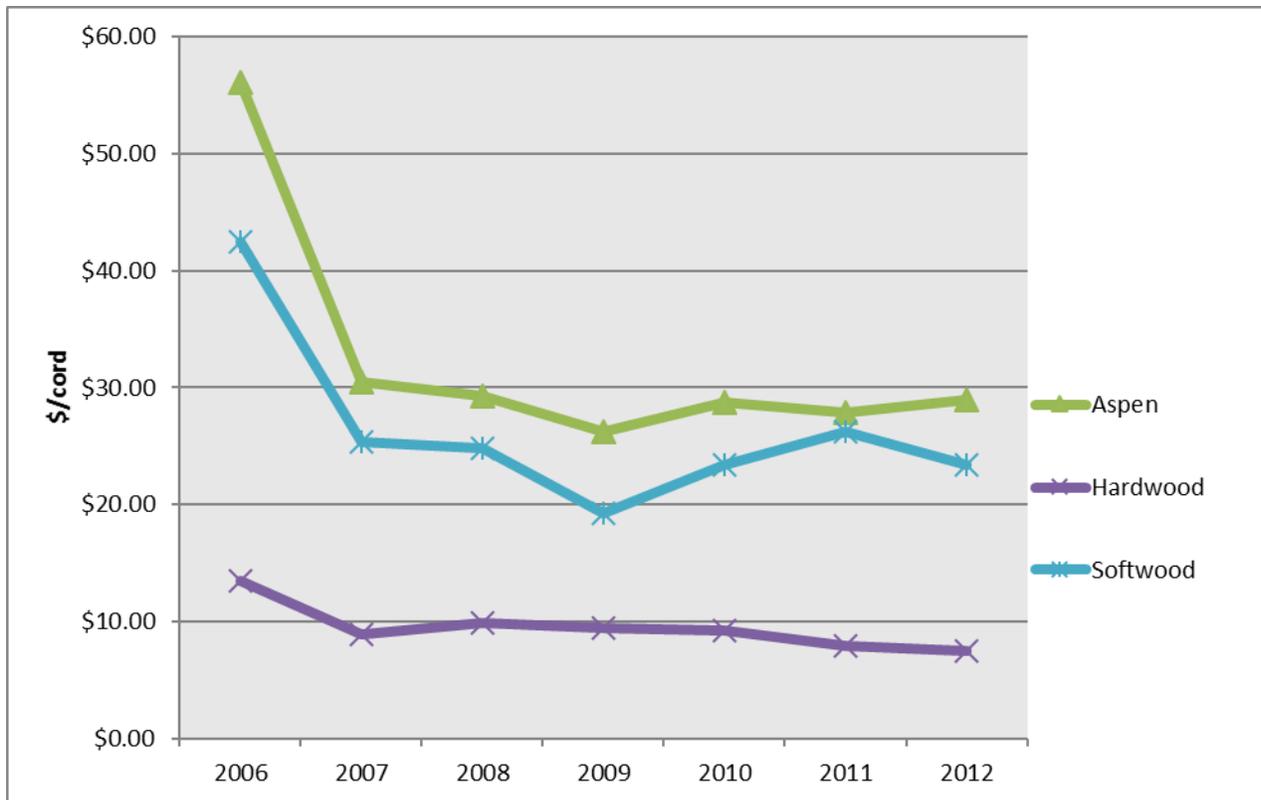
Figure 5. Stumpage price per cord from 2006-2012 within the SLCLD by species category[1-6].

[1]Stumpage prices calculated by taking the volume weighted average value for each species and aggregating weighted values into the specified species category.
[2] Volume weighted average value = (volume weighted sum of each species x average price of each species).
[3] Average prices calculated by volume weighted (mean) total value by total volume for each listed species.
[4]Majority of cords reported in the stumpage review are listed as pulpwood.
[5]Species that were listed as thousands of board feet (MBF) (e.g., sawtimber) or tons (e.g., biomass) were not included, as the report only reported small volumes.
[6] *Source*: MN DNR Stumpage Price Review and Price Index (2006-2012).

Volume Density (Appraised Cords per Acre)
As the SLCLD sales data contains a wide range of tract sizes and total sale volumes, the appraised cords per acre were used to describe volume density. The per acre unit of measurement helps minimize the relative influence of larger tracts on the dependent variable (e.g., larger tracts generate more gross timber sale revenue compared to smaller tracts because they have more volume). The volume density variable is calculated by dividing the total appraised volume by total sale acres. Brown et al. (2012) noted that increased volume density allows buyers to harvest more volume in a shorter period of time due to more efficient harvesting operations (e.g., harvesters spend less time traveling from tree to tree). MacKay and Baughman (1996) also report a positive correlation between volume density and stumpage prices. Other studies have reported that volume density has no impact on stumpage prices (Buongiorno and Young, 1984; Munn and Rucker, 1995; Carter and Newman, 1998; Leefers and Potter-Witter, 2006). It is hypothesized that increased volume density (i.e., appraised cords per acre) would have a positive impact on gross timber sale revenue per acre.

Location

The location variable specifies the region of each tract within the SLCLD. The dataset indicates whether the tract was located in the north or south area of the county (1 = southern area and 0 = northern area). It is hypothesized that the southern area would generate more gross timber sale revenue per acre compared to the northern area due to the shorter hauling distance to consuming mills. Longer distances to the consuming mills create higher hauling costs and tie up trucks for longer periods of time for the buyer. There are two large pulpwood mills (i.e., Sappi and Verso) that are located near the far southern edge of St. Louis County. The south region also provides better access to mills in Wisconsin and Michigan. The hypothesis behind the southern area premium is founded on the proximity to the end market; bidders discount their bids to account for the higher hauling costs. Previous studies, such as Puttock et al. (1990) and Niquidet and Kooten (2006) also indicated that increased hauling distances (higher cost) reduced stumpage prices.

Auction Type (Sealed bid)

The auction type variable assesses the impact of sealed bid and oral auctions on gross timber sale revenue. The SLCLD utilizes both auction types, with 56% of all timber sales between 2006 and 2012 auctioned using the sealed bid method. Johnson (1979) found that sealed bid auctions generated higher stumpage prices than oral auctions. Furthermore, Johnson (1979) noted that the theoretical argument for using sealed bid auctions was to reduce collusive activity and inferred that sealed bid auctions were generally utilized in noncompetitive markets. The latter argument is a major reason why public agencies utilize sealed bid auctions, as timber sales often have few bidders. Therefore, if bidders do not know the level of competition, as in sealed bid auctions, they will, in theory, submit their true WTP (Wiener, 1979). The level of competition is known in oral auctions, since bidders are present and openly submitting ascending bids; therefore, bidders will not continue bidding up a tract if there is no competition. Similar to Johnson (1979), it is hypothesized that sealed bid auctions will increase gross timber sale revenue per acre due to limited competition for SLCLD timber sales. In other words, bidders will submit higher bids due to a lack of information on level of competition.

Harvesting Blocks

Public timber sales often include several harvesting blocks (stands or groups of stands) in a single timber sale. If the blocks within a sale are widely dispersed, the buyer might incur higher costs when moving harvesting equipment between the blocks. The SLCLD utilizes sale blocks for many sales, but the majority of timber sales from the SLCLD dataset had three harvesting blocks or less. It is hypothesized that increased number of harvesting blocks will decrease gross timber sale revenue per acre, as buyers will discount their bids to account for the higher cost of moving harvesting equipment to each block.

Winter

The winter binary variable controls for the season in which buyers are permitted to harvest the sale. A binary dummy variable (1=winter only and 0=summer only / year round) is created to investigate whether the winter harvest restrictions influence the gross timber sale revenue per acre. SLCLD prescribes winter only harvest restrictions (i.e., frozen ground harvests) on 56% of their sales (Table 5) to reduce the potential of compaction and degradation on fine textured soils and in lowland sites. The summer access / year round category permits buyers to harvest during the summer or with no seasonal restrictions. MacKay and Baughman (1996) reported that sales

with winter only harvest restrictions reduced the predicted stumpage prices by $0.54 per cord. It is hypothesized that gross timber sale revenue per acre on SLCLD timber sales with winter only harvest restrictions would be discounted compared to sales with summer only / year round harvesting access.

Season of Sale (Quarter [1-4])

The season (quarter) of sale can significantly influence stumpage price markets. Dahal and Mehmood (2005) reported stronger stumpage prices in the fall for timber sales in the southern U.S. They theorized that this premium was driven by the drier conditions in the fall, which allows buyers to immediately harvest the tracts, since wet conditions would restrict harvesting operations. Brown et al. (2012) also inspected season of sale and found that MN DNR stumpage prices were significantly higher in the second quarter of the calendar year compared to the fourth quarter. The authors hypothesized that a buyer's demand for timber varies throughout the year. The SLCLD generally conducts one auction for each quarter of the calendar year (i.e., February, May, August and November), and the number of tracts offered each quarter does not vary significantly between auctions (SLCLD dataset). It is hypothesized that season of sale influences gross timber sale revenue per acre due to increased demand for timber sale contracts in the quarters leading up to the winter harvest season, since the majority of timber sales are harvested during the winter in St. Louis County.

Year [2006-2012])

The year variable indicates the year in which the timber sale auction was conducted. A year binary variable accounts for the fluctuations in market conditions from one period to the next (Buongiorno and Young 1984). Brown et al. (2012) used dummy year variables to control for the end product market conditions. In this current study, once the timber on a tract has been purchased, the unit bid price does not change within the contract period. The year of harvest is not included in the model because it only indicates the year in which the SLCLD closed the sale. A timber harvest can occur over the course of several years; and therefore, the year the SLCLD closed the sale does not necessarily represent the time period in which a sale was harvested. Because the year of harvest is not included within the model, any changes in stand volume due to increased growth or mortality or the strength of market conditions at the time of harvest are not captured in the model. Due to the drop in stumpage prices in 2005 and 2006, 2006 is used as the omitted variable and it is hypothesized that the years 2007-2012 would generate lower gross timber sale revenue per acre than 2006 (Table 3).

Results

The F-statistic for the gross timber sale revenue model indicates that the included variables are jointly significant at the 1% level (Table 6). In addition, the R^2 shows that the model explains approximately 65% of the variation in gross timber sale revenue per acre, suggesting the model is useful for estimating the gross timber sale revenue per acre. Several variables have a statistically significant influence on gross timber sale revenue per acre at the 1% significant level, including hardwood, appraised cords per acre, location, winter, and year.

The following sections provide a summary of the timber payment method, as well as the statistically significant (1% level) predictors of gross timber sale revenue per acre for SLCLD timber sales closed between 2006 to 2012.

Table 6. Results from the OLS hedonic regression (dependent variable = gross timber sale revenue per acre) for timber sales closed by the SLCLD from 2006-2012 (n = 473).

Independent variable	Coefficient[1]	S.E.	95% C.I.	
Intercept	199.98***	52.91	96.01	303.95
SOAV	29.27	24.62	-19.12	77.66
Hardwood	-367.79***	44.87	-455.97	-279.61
Aspen	-13.04	34.34	-80.52	54.44
Appraised cords per acre	25.50***	1.11	23.31	27.69
Location	44.75***	16.99	11.36	78.14
Sealed bid	8.91	15.14	-20.84	38.66
Blocks	-5.07	6.56	-17.96	7.81
Winter	-73.58***	15.59	-104.21	-42.94
Q1	38.95*	23.46	-7.15	85.04
Q2	8.10	21.51	-34.16	50.37
Q3	18.44	21.99	-24.78	61.66
Year07	-132.66***	38.98	-209.26	-56.06
Year08	-171.52***	39.32	-248.80	-94.24
Year09	-221.43***	41.06	-302.12	-140.73
Year10	-171.53***	42.92	-255.88	-87.18
Year11	-177.59***	43.48	-263.04	-92.15
Year12	-225.51***	49.50	-322.79	-128.24

Model Fit:
R^2 = 0.6524
Adj. R^2 = 0.6386
F-statistic = 47.34 (Pr <0 .0001)

[1]*** = significant at 1% level; * = significant at 10% level.

Timber Payment Method (SOAV)

The results of the gross timber sale revenue model indicate that the SOAV variable is not significant at the 10% level. Therefore, the model fails to reject the null hypothesis that there are no differences in gross timber sale revenue attributed to the timber payment method. While the finding highlights that timber payment method is not a significant predictor of gross timber sale revenue per acre, it is possible for timber payment method to be a significant predictor of a bidder's WTP. This scenario is unlikely because the gross timber sale revenue model's dependent variable is comprised of both components of gross timber sale revenue (i.e., WTP for timber and merchantable volume). Therefore, if timber payment method does not influence gross timber sale revenue per acre, then it will not likely impact WTP. The winning bid value model presented in section 2.2 investigates whether timber payment method creates differences in WTP for timber.

Hardwood

The hardwood variable is significant at the 1% level, affirming the hypothesized negative impact of hardwood species on gross timber sale revenue per acre. The hardwood parameter estimate indicates that for a one unit change in hardwood (0.0 to 1.0 hardwood volume) gross timber sale revenue per acre would decrease by approximately $368 per acre, holding all else constant. The negative influence on gross timber sale revenue is likely due to the relatively low price levels for hardwood species (Figure 5). The charts in Appendix B also show that the SLCLD hardwood

species sold from 2006 to 2012 were predominantly birch, ash, and maple, which yield much lower prices per cord than aspen or softwood species.

Volume density (Appraised Cords per Acre)

The appraised volume per acre variable is statistically significant at the 1% level. The parameter estimate for this variable indicates that an increase of one cord per acre increases gross timber sale revenue per acre by $26, holding all else constant. The results in Brown et al. (2012) also found that an increase in volume density increased MN DNR stumpage prices.

Location

The location dummy variable is statistically significant at the 1% level, which indicates that a tract sold in the southern area of St. Louis County generates approximately $45 more per acre than a tract sold in the northern area, holding all else constant. As compared to the southern part of the county, the northern area had a higher percentage of softwood species volume appraised, a lower percentage of hardwood species appraised volume, and a slightly higher percentage of aspen species appraised volume for tracts which closed from 2006-2012 (Table 7). Therefore, the southern area premium is likely driven by something other than species composition. The end product market for species, combined with the markets available to the buyer, determines the consuming mill, which dictates the hauling distance. There are several regional pulpwood consuming mills that might utilize SLCLD timber sales. Two large pulpwood consuming mills, Sappi and Verso, are located near Duluth, MN, which is the southernmost point of St. Louis County. The Sappi and Verso mills purchase aspen, maple, balsam fir, spruce, and small amounts of pine. Other end markets that are potential options for St. Louis County timber sales include Boise (International Falls), UPM (Grand Rapids), Louisiana-Pacific (Two Harbors), and several consuming mills in Wisconsin (MN DNR, 2014). These mills purchase mainly aspen and softwood species (MN DNR, 2014) and several procure timber from the southern part of the county. Therefore, the northern area sales which have large volumes of aspen and softwood species (e.g., balsam fir and spruce) have fewer market options and longer hauling distances (i.e., higher costs), compared to southern area timber sales. Consequently, stumpage buyers are likely discounting their bids on northern area sales to account for the higher hauling costs.

Table 7. Percent of appraised volume sold by species category within each SLCLD area office for tracts which closed from 2006-2012 (n=473).

Area office[1]	Aspen[2]	Hardwood	Softwood
Southern	42.3%	29.3%	28.4%
Northern	49.7%	14.0%	36.3%

[1] Northern is the Virginia area and southern is the Pike Lake area.

[2] Aspen, hardwood, and softwood percentages were based on the appraised volumes sold from 2006-2012 in each area.

Winter

Results from the gross timber sale revenue model indicate that the winter variable is statistically significant at the 1% level. Winter only sales generate approximately $74 less timber sale revenue per acre than a summer / year round access sale, holding all else constant. This finding supports the hypothesis that buyers' are willing to pay significantly higher prices for summer / year round access. The winter only harvesting restriction is an important site protection/ management tool for public agencies as it minimizes the environmental impact of harvesting operations. However, where nonwinter harvesting is a viable option, agencies can expect to

generate more gross timber sale revenue as some buyers would likely pay premiums to harvest throughout the year. Some logging companies operate year-round to generate income throughout the entire year in order to offset their monthly fixed costs (e.g., equipment loan payments, insurance payments). In order to operate year-round, a logging firm may seek to diversify its harvest seasons and pay higher prices to secure the non-winter tracts. Also, mills seek to maintain fresh wood supplies year-round, and thus are interested in purchasing stumpage during all seasons.

Year [2006-2012])

The gross timber sale revenue model shows that all year variables (Year07-Year12) are significant at the 1% level. Each year variable (i.e., Year07 -Year12) is assessed against 2006. The results show that Year07 through Year12 generate substantially less gross timber sale revenue per acre (ranging from $133 to $226 less per acre) than the 2006 base year, which corresponds with the higher stumpage prices generated by SLCLD in 2006 relative to 2007-2012 (Figure 5). Stumpage prices in Minnesota dropped sharply from 2006 to 2007, bottomed out in 2007/2008, and remained relatively flat through 2012 (Figure 5). The gross timber sale revenue model's estimate of the influence in year-to-year market price fluctuations is likely driven by the large drop in timber prices after 2006 (Figure 5). Brown et al. (2012) found that strong end product markets (i.e., stronger demand from consuming mills) from 2001-2006 drove up stumpage prices, and similarly, the model finds that the comparatively weaker stumpage markets from 2007 to 2012, relative to 2006, decreased SLCLD's gross timber sale revenue per acre.

2.2. Winning Bid Value Model

The winning bid value model assesses whether timber payment method influenced a bidder's WTP for timber. Utilization of merchantable volume is likely different between timber payment methods because estimated volume (SOAV) and scaled volume (consumer scale) frequently vary (Table 2); however, its impact on gross timber sale revenue is not fully understood. In order to directly evaluate the utilization differences between timber payment methods, data on scaled volume is needed. Since the scaled volume data for both timber payment methods is unavailable, the differences in utilization of merchantable volume are calculated by deriving the gross timber sale revenue and WTP for timber terms shown in Equation 1. The winning bid value model determines whether there are differences in WTP for timber between timber payment methods, while the gross timber sale revenue model determines whether there are differences in gross timber sale revenue.

In the winning bid value model, the dependent variable is the winning bid value per acre. The winning bid value is the estimated (appraised) volume for each species, multiplied by the unit bid price for each species-product combination. Unlike in the gross timber sale revenue per acre model, the winning bid value model used estimated volumes and unit bid prices for all observations, including consumer-scale and blended sales (Table 8). It is assumed that the estimated volumes between timber payment methods are not different, because the SLCLD use the same appraisal standards for all timber sales. Therefore, if the timber payment method significantly influences the winning bid value, the variation would be attributed to differences in a bidder's WTP.

Table 8. Overview of how the winning bid value was determined for each timber payment method.

Timber payment method	Merchantable volume		Willingness to pay		Winning bid value differences
SOAV	estimated (appraised) volume	x	unit winning bid price by species-product composition	=	winning bid value (per acre)
Consumer scale	estimated (appraised) volume	x	unit winning bid price by species-product composition	=	winning bid value (per acre)

The null hypothesis is that there are no differences in winning bid value attributed to timber payment method. Winning bid value per acre is a proxy for WTP for timber. It was hypothesized that timber payment method would create differences in WTP for timber due to the increased merchantable volume on SOAV sales, which would drive bid premiums on SOAV sales volume. It was also hypothesized that the forester who appraised the timber sale influences a bidder's WTP for timber (section 2.1); however, this study does not formally examine the influence of individual appraisers on WTP for timber, so the degree and direction of influence of the individual appraiser is not known.

Model Specification
The winning bid value model utilized the same 473 SLCLD observations and independent variables that were included in the gross timber sale revenue model (Table 3). The analysis uses SAS 9.3 for the winning bid value model. The important difference between the two hedonic price models is the dependent variable. While the gross timber sale revenue model used the actual gross timber sale revenue per acre as the dependent variable, the winning bid value model uses the winning bid value.

Equation 3 represents the hedonic price winning bid value model for SLCLD timber sales:

$$\textit{Equation 3. } \text{Winning bid value (\$/acre)} = \alpha_i + \sum \beta_j x_i + \varepsilon_i$$

The x_i's in Equation 3 are the tract characteristics that could influence the winning bid value per acre received by the SLCLD (Table 3), and β_j's are the parameter estimates indicating the direction and relative strength of the relationship with respect to winning bid value per acre. The term α_i is the intercept parameter, and ε_i is the error term.

Similar to the gross timber sale revenue model, the plot of residual and predicted values showed that the winning bid value model did not have a trend in the error term, indicating an appropriate functional form. A Box-Cox test indicated that no transformations were necessary. The Pearson Correlation Coefficient (PCC) test showed that the softwood variable had a high negative correlation with both aspen and hardwood categories and therefore was omitted from the estimated model. The dependent variable (winning bid value per acre) is the only variable unique to this model, as both models used the same independent variables.

Results
The winning bid value model's F-statistic indicates that the included variables are jointly significant at the 1% level, and the R^2 highlights the models' explanatory power with

approximately 75% of the variation in winning bid value explained (Table 9). With the exception of the Quarter variables, all of the included variables in this model are similar in statistical significance and direction as the gross timber sale revenue model. Because their interpretation is similar here as under the gross timber sale revenue model, only the Quarter and timber payment method variables' influence on the winning bid value are described below.

Table 8. Results from OLS hedonic regression (dependent variable = winning bid value per acre) for timber sales closed by the SLCLD from 2006-2012 (n = 473).

Independent variables	Coefficient[1]	S.E.	95% C.I.	
Intercept	74.65*	47.61	-18.90	168.21
SOAV	28.47	22.16	-15.07	72.01
Hardwood	-345.84***	40.38	-425.19	-266.49
Aspen	-38.20	30.90	-98.92	22.52
Appraised cords	30.73***	1.00	28.76	32.70
Blocks	-2.07	5.90	-13.66	9.53
Location	33.50**	15.29	3.45	63.55
Sealed bid	19.40	13.62	-7.37	46.17
Winter	-65.82***	14.03	-93.39	-38.25
Q1	50.62**	21.11	9.14	92.09
Q2	34.40*	19.35	-3.63	72.43
Q3	35.33*	19.79	-3.56	74.22
Year07	-141.63***	35.07	-210.55	-72.71
Year08	-179.89***	35.38	-249.43	-110.36
Year09	-230.14***	36.95	-302.75	-157.53
Year10	-171.88***	38.62	-247.78	-95.98
Year11	-156.29***	39.12	-233.17	-79.41
Year12	-167.85***	44.54	-255.38	-80.32

Model Fit:
$R^2 = 0.7535$
Adj. $R^2 = 0.7438$
F-statistic = 77.11 (Pr < 0.0001)

[1]*** = significant at 1% level, ** = significant at the 5% level, and * = significant at 10% level.

Timber Payment Method (SOAV)
The results of the winning bid value model indicate that the SOAV variable is not significant at the 10% level. Therefore, the model fails to reject the null hypothesis that there are no differences in gross timber sale revenue attributed to the timber payment method.

Quarter (1-4)
The Q1 (January-March) variable in the winning bid value model is significant at the 5% level, and the Q2 (April-June) and Q3 (July-September) variables are significant at the 10% level (Table 9). In contrast, Q1, significant at the 10% level, is the only statistically significant quarter in the gross timber sale revenue model (Table 6). The omitted variable in both hedonic price models was Q4 (October-December). These results suggest that demand for SLCLD timber sales, as represented by stumpage bid prices, is strongest in the first quarter. In fact, a tract sold in the first quarter generated approximately $51 more per acre than a tract sold in the fourth quarter, holding all else constant. In addition, tracts sold in Q2 and Q3 generate approximately $35 more per acre than sales in Q4, holding all else constant.

A potential reason for the quarter variable's findings is the seasonal changes in consuming mills' demand for timber. Brown et al. (2012) found that October-December timber sales had the highest observed MN DNR stumpage prices and attributed this premium to the buyer's need to secure stumpage and fulfill their timber contracts. Additionally, Brown et al. (2012) found the lowest MN DNR stumpage prices were in April-June and suggested that it was associated with the end of the winter harvesting season (Minnesota's spring breakup usually occurs in March/April). Therefore, Brown et al.'s (2012) findings contradict the results found in the winning bid value model where Q4 (October-December) generated the lowest stumpage prices, as opposed to the highest stumpage prices.

The SLCLD dataset have comparable numbers of timber sales spread across the four quarters (Table 5), and the nonwinter harvesting premium timber sales are spread out relatively even across each of the quarters. Therefore, the Q4 discount is not likely attributed to more winter only timber sales (i.e., winter only sales' discount), compared to Q1-Q3. However, the mean winning bid value is lowest for timber sales sold in Q4 and highest for timber sales sold in Q1; therefore, it is speculated that the Q1-Q3 stumpage price premiums are due to increased cash flow after the winter harvesting season. However, the Q1, Q2, and Q3 bid premiums might also be related to an omitted variable bias in which a relevant variable is not included in the model (Wooldridge, 2013).

2.3. Paired Bidding Experiment

Regression methods only control for the variation of the included variables (independent variables) and allow a portion of the variation to be left unexplained (error term). The error term contains unobserved factors that affect the dependent variable and might also include measurement errors in the observed dependent or independent variables (Wooldridge, 2013). The winning bid value model (section 2.2) controls for all of the observable characteristics[19] included in the model to estimate the relative influence of timber payment method on bid price; however, it does not control for the unobservable characteristics[20] influencing WTP.

Since regression methods do not completely control for all sources of variability (i.e., observable and unobservable characteristics), a paired bidding experiment was conducted to provide another perspective on timber payment method's influence on WTP. The paired bidding method complements the regression methods used in the bid price model because it controls for all timber sale factors (both observed and unobserved) that are known to the seller and buyer, except the variable of interest (Kilgore and Blinn, 2003). The method does not reveal the influence of unobserved features of a timber sale, but rather it controls for them. The variable of interest in the paired bidding experiment was the timber payment method, and similar to the bid price model, the experiment analyzed the relative influence of timber payment method on a bidder's WTP (i.e., bid price).

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[19] Observable characteristics are the features of a timber sale that are known by the seller and buyer, which include size of the sale, estimated volume, location of the tract, etc.
[20] Unobservable characteristics are the features of a timber sale that are not known to the seller but are known to the buyer, which include the buyer's logging experience, the current inventory and location of stumpage held by potential buyers, information about the contracts that buyers have with consuming mills, etc.

Experimental Design

When applied to stumpage sold at an auction, the paired bidding method requires a timber tract to be offered through a sealed bid process to potential buyers under two scenarios and for the buyer to submit a sealed bid for each scenario. A tract is offered with the two treatments but all other attributes of the sale (e.g., location, tract size, volume per acre) remain unchanged. Each buyer interested in the paired bid sale must submit two bids for the timber tract—one for the tract with treatment A (e.g., SOAV timber payment method) and one for the tract with treatment B (e.g., consumer-scale timber payment method) and the sale is awarded to the highest bidder for the treatment selected. The selected treatment for each tract (i.e., pair) is randomly determined (e.g., through the flip of a coin). Because the paired bidding method efficiently controls for all variation in timber sale attributes, except for the selected variable of interest (i.e., timber payment method), one can isolate the effect of the variable of interest on stumpage bids. Since the method resulted in the actual sale of timber, the potential for strategic behavior on the part of bidders (i.e., bids not reflective of their true WTP) is minimized, if not eliminated altogether (Kilgore and Blinn, 2003). The paired bidding technique in this analysis evaluated how each timber payment method impacted a bidder's WTP.

On February 20, 2014, the SLCLD paired bidding experiment was implemented to evaluate how the two timber payment methods impact stumpage bid prices. The experiment was administered by the SLCLD staff through their sealed bid auction process. The SLCLD staff began the experiment by sending out a notice of sale on January 13, 2014, to prospective buyers with the paired bidding instructions for the February 20, 2014 auction; therefore, the prospective buyers were given 37 days to visit the timber tracts for sale. All bidders were allowed to participate in the SLCLD auction regardless of firm size. A draft of the paired bidding instructions was provided by the University of Minnesota research team conducting the timber payment method study, revised where appropriate by SLCLD personnel, and then included with the notice of sale (Appendix C).

The paired bidding experiment required bidders to submit two bids for each timber tract they were interested in bidding on: one bid for the tract with a SOAV treatment and one bid for the same tract with a consumer-scale treatment. A special auction form was used for the SLCLD paired bid tracts (Appendix D). All buyers were notified of the special bidding procedures and instructed that any bid without both Version A (SOAV) and Version B (consumer scale) would not be considered valid. The treatment (i.e., Version A and Version B) for each paired bidding tract was selected through the flip of a fair coin. The randomized treatment selection was performed and video recorded after the sealed bid auction was closed to bidders at 4:30 p.m. on February 20, 2014. Once all paired bid tracts were assigned a treatment, the treatment assignment results were sent to the SLCLD and they determined the winning bid for each tract (i.e., the winning paired bid tract was the highest bid for the treatment selected for each tract). The bids under the treatment that was not selected by the coin flip were not considered in the final selection of the winning bidder and were removed from the auction. There were no bidders that submitted the paired bids incorrectly (e.g., only submit one bid and not paired bids); therefore, all bidders followed the paired bidding instructions (Appendix C). A total of 16 tracts were offered for sale and 15 timber tracts were sold through the paired bidding auction, generating 84 paired bids. One paired bidding tract did not receive any bids and was not sold at the February 2014 auction. The results of the 84 paired bids were sent to the University of

Minnesota research team shortly after the tracts were assigned to the winning bidders, and the results were analyzed.

Results

For each paired bid, the value difference between timber payment method treatments (i.e., SOAV bid value minus consumer-scale bid value) was calculated (Figure 6). Any values below the baseline had higher bids for the consumer-scale treatment and values above the baseline had higher bids for the SOAV treatment. The vast majority of paired bids (69 of the 84 bids) did not differentiate between timber payment methods. Of the 15 bids that were differentiated, the consumer-scale treatment had slightly more bid premiums than the SOAV treatments (i.e., nine bid premiums for consumer scale and seven for SOAV).
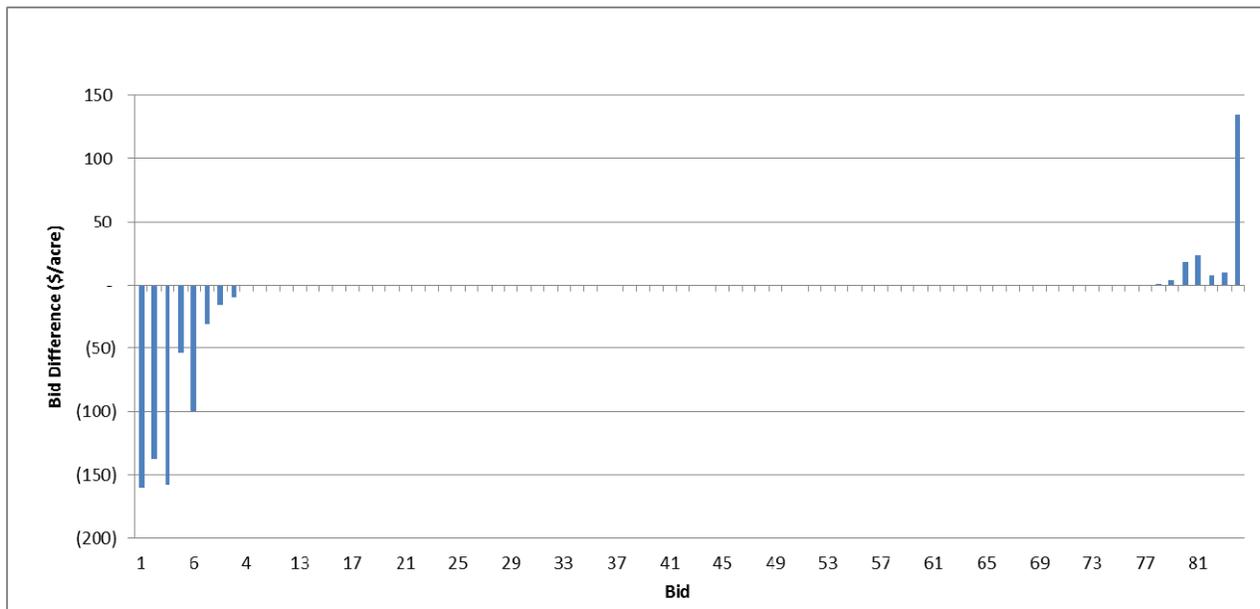
Figure 6. Paired bidding timber payment method experiment results from the SLCLD's auction on February 20, 2014. The bid difference (y-axis) is shown in dollars per acre for the SOAV bid minus the consumer-scale bid (n = 84 paired bids).

Table 10 shows the various bid preference options on the 15 paired bid tracts. All 15 tracts had at least one bidder that did not differentiate their paired bids (i.e., SOAV = consumer scale); however, the results show that bid premiums are both unidirectional (e.g., bid premium for one timber payment method on a given tract) and bidirectional (e.g., bid premium for both timber payment methods on a given tract). The unidirectional bids include the sales that had only SOAV premiums (one tract) or only consumer-scale premiums (three tracts) on the paired bids. The four bidirectional tracts had at least one bid premium for SOAV and at least one bid premium for consumer scale. The instances of bid premiums for either timber payment method are few (15 paired bids), compared to the tracts that have no difference in paired bids (69 paired bids). Therefore, it appears that bidders seldom differentiate their bids based solely on timber payment method, and when they do, it is not necessarily unidirectional.

Table 9. Bid preference results from the SLCLD paired bidding auction.

No bid difference[1]	Unidirectional SOAV premium[2]	Unidirectional consumer-scale premium[3]	Bidirectional bids[4]	Total sales
7	2	3	3	**15**

[1]No bid differences is the number of paired bid tracts with no differentiated paired bidding values.
[2] SOAV premiums are the total number of paired bid tracts with at least one SOAV premium, no consumer-scale premiums, and the remaining paired bids with zero differentiation.
[3] Consumer-scale premiums are the total number of paired bid tracts with at least one consumer-scale premium, no SOAV premiums, and the remaining paired bids with zero differentiation.
[4] Bidirectional bids are the total number of paired bid tracts where there was at least one SOAV premium, at least one consumer-scale premium, and the remaining paired bids with zero differentiation.

A paired t-test was used to explore the paired bidding population means and to test the significance of the mean difference between the 84 consumer-scale and SOAV samples (Wooldridge, 2013). The paired t-test for sample means tests the null hypothesis on WTP (section 2.2) that there are no differences in a bidder's WTP between the SOAV and consumer-scale timber payment method. The 84 observations in the paired t-test are the total bid values for each of paired bids.

The results from the paired t-test (Table 11) indicate strong correlation between the two variables (Pearson Correlation Coefficient of 0.9908), which is not surprising, considering the paired bidding method only allowed for variation in the timber payment method. The mean values of timber sales for the SOAV and consumer-scale paired bids are $52,174 and $53,057, respectively. The paired t-test found that the difference in sample means was not statistically different from zero at the 10% level; therefore, the paired bid experiment fails to reject the null hypothesis that there are no differences between WTP for timber under the two payment methods. This finding is similar to the results in the winning bid value model (section 2.2), which also found that timber payment method did not influence the WTP for timber.

Table 10. Results of the paired t-test of the SLCLD's paired bidding data (n = 84).

Factor[1]:	SOAV bid	Consumer-scale bid
Mean	$52,174	$53,057
Model Fit:		
Pearson Correlation = 0.9908		
P(T<=t) two-tail = 0.1283		

[1]The paired t-test was computed using Microsoft Excel 2010.

2.4. Chapter Summary

Chapter 2 explored the timber sale features that drive gross timber sale revenue and focused specifically on the impact the timber payment method has on gross timber sale revenue. The initial hypothesis claimed that the SOAV timber payment method would drive gross timber sale revenue higher due to increased utilization on SOAV sales compared to consumer-scale sales; however, the collective analysis described in Chapter 2 found that timber payment method did not create differences in merchantable volume.

Gross timber sale revenue and WTP were two of the three terms in the gross timber sale revenue equation (Equation 1) that were analyzed using the hedonic price analyses and a paired bidding experiment. The gross timber sale revenue model found that several timber sale features did significantly influence gross timber sale revenue per acre, including the composition of

hardwood species within the timber sale, volume density (i.e., appraised cords per acre), location within the two area offices, whether the tract could only be harvested during the winter due to season restrictions, and the year in which the tract was sold. However, the variable of interest in this study, timber payment method, was not found to influence gross timber sale revenue per acre in section 2.1. The winning bid value model (section 2.2) and the paired bidding experiment (section 2.3) demonstrated that timber payment method does not influence the WTP for timber. Since the timber payment method did not result in any significant differences in the gross timber sale revenue or WTP for timber, it was concluded that there were no differences in utilization of merchantable volume between the two payment methods. The differences in utilization of merchantable volume were derived by estimating two of the three terms in the gross timber sale revenue equation (Equation 1). Since the gross timber sale revenue and WTP terms were both zero (no differences), the merchantable volume differences must also be zero. Prior to the findings in this study, it was hypothesized that the SOAV method would create higher gross timber sale revenue due to increased utilization of an SOAV timber sale. However, the analysis failed to reject the null hypotheses that there are no differences in gross timber sale revenue attributed to the timber payment method, based on the findings in sections 2.1, 2.2, and 2.3.

3. Total Administrative Cost Differences

This chapter identifies and analyzes the SLCLD's administrative costs associated with the SOAV and consumer-scale timber payment methods. While there are aspects of each timber payment method that are similar within the SLCLD (e.g., timber cruising administration, down payment requirements), the analysis focused on the administrative features that distinguish each payment method. For most public timber programs, there are three main cost areas associated with the timber payment method that vary based on the method used. These are appraising the merchantable volume in a timber sale through a timber cruise (section 3.1), administering the consumer-scale ticketing process (section 3.2), and the in-woods scaling of harvested wood by the agency (section 3.3). Similar to Chapter 2, the agency's administrative cost information was provided by SLCLD administrative staff.

3.1. Cost of Timber Cruising

The cost of estimating a timber sale's merchantable volume can vary based on the timber payment method used. Many timber sale programs have a more rigorous timber appraisal standard for SOAV sales (i.e., more time spent appraising a stand) to reduce the financial risk of volume estimation errors. The SLCLD does not differentiate cruising intensities between timber payment methods (i.e., no cost differences). It requires that all estimates of a timber sale's merchantable stand volume have an accuracy of ±20% of actual stand volume for the stand's "major species[21]" and ±15% of actual stand volume for all species combined (Jason Meyer of the SLCLD, personal communication, 2014). Because the SLCLD does not impose different timber cruising accuracy standards for the two timber payment methods, this analysis assumes there is

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[21] **Major species** are a single or aggregate of species (e.g., aspen might include bigtooth aspen, quaking aspen, and balm of gilead) comprised of at least 60% of the estimated volume of the sale, according to the SLCLD (Jason Meyer, personal communication, 2015).

no difference in cost to SLCLD under the two payment methods that is attributed to the field work and subsequent data processing needed to prepare a tract of timber for sale.

3.2. Cost of Administering the Ticketing Process

The consumer-scale timber payment method is generally the only payment method that requires a ticketing system. One exception is the MN DNR, which implements a ticketing system on both consumer-scale and SOAV sales. The SOAV ticketing process for MN DNR timber sales was instituted to adhere to third party forest certification requirements. The SLCLD does not require a ticketing system for SOAV sales.

With a consumer-scale ticketing system, scaling tickets must be tracked to account for each harvested unit of timber. Ticketing systems require several steps that involve both the buyer and seller (section 1.1). The purpose of this cost analysis is to investigate the total cost of administering the consumer-scale ticketing system to the public agency. Detailed time information was collected from SLCLD on the ticketing process in its entirety to estimate the total cost of administering the consumer-scale ticketing process. The analysis calculated the total estimated cost for all consumer-scale tickets processed in a year, which included the ticketing process cost for 100% consumer scale and consumer-scale portion of blended sales.
To assess the total administrative cost of processing consumer-scale tickets, the SLCLD administrative staff recorded the time spent on each step of the ticketing process. There are five administrative tasks in the ticketing process: (1) stamping and mailing, (2) opening and recording, (3) entering data, (4) closing the sale, and (5) billing and refunds. These five discrete tasks were identified through discussions with SLCLD staff that process outgoing and incoming scaling tickets.

The time needed to administer each of the five tasks was collected and subsequently used to calculate the cost of administering the SLCLD ticketing process. The first four tasks were recorded by SLCLD area office staff (area administrators) and the fifth task was recorded by the SLCLD downtown office staff person (downtown administrator). The area offices are located in Pike Lake and Virginia, and the downtown office is in Duluth, MN. The three administrators selected to record the time study information were longstanding SLCLD administrators with many years of experience in each of their respective administrative tasks.

The time spent on tasks 1 to 3 was recorded by SLCLD area administrators during the following periods: July 30, 2013, to August 30, 2013, and February 5, 2014, to March 5, 2014. The first time period was used to test the data collection process, and the second time period was used to ensure that data was collected during the busiest time of the year in order to obtain as much time study information as possible. The time spent on task 4 (sale closing) was separately recorded by SLCLD area administrators on a total of 15 sale closings that occurred between August and November 2014. SLCLD area administrators also recorded the time spent working on "problem tickets" during July 30, 2013, to August 30, 2013, and February 5, 2014, to March 5, 2014, which was incorporated into the total cost of administering a consumer-scale ticketing system. To gather the information needed for tasks 1 to 4, each area administrator recorded the minutes they spent each day processing tickets (by task), as well as the total number of tickets processed that day during the data collection periods (Appendix E). When area administrators encountered

problem tickets during tasks two and three; they tracked the time spent working on those tickets. The SLCLD ticketing process is illustrated in Figure 7.

The fifth task was completed by the downtown administrator who oversees all timber sale billings and refunds once a timber sale is closed by an area field office. This administrator issues refunds and submits invoices for final billings once a sale has closed. Because the fifth task is distinct from the first four tasks, the time spent on this task was tracked separately over a seven-week period from March 7, 2014 through April 29, 2014, which is the busy season for billings and refunds. Figure 7 presents the entire ticketing process for consumer-scale sales in the SLCLD; therefore, each task is represents an additional cost of the consumer-scale timber payment method.

Administrative costs for consumer-scale ticketing that were not included in this analysis include the time spent sending booklets to the buyer, the time spent posting the lockbox at the harvest site (section 1.1), and the time spent collecting tickets from the lockbox after the sale closes. There are also nonadministrative costs related to the consumer-scale ticketing system (e.g., upfront cost of information system for timber sale data, information system maintenance, software upgrades); however, the only nonadministrative cost included in the consumer-scale ticketing process analysis was the cost of printing the tickets.

The sections below describe the methods used to calculate the total administrative costs of the ticketing process for consumer-scale sales. Each section also includes an analysis of the results.

Cost of Area Administration: Tasks 1-4
The area administrative costs represent the time spent on tasks 1 to 4 of consumer-scale ticketing process. Each area administrator recorded the number of minutes spent on the first four tasks (Figure 7) for 74 days. The four administrative tasks for which time was recorded were stamping and mailing, opening and recording, entering data, and closing the sale (Figure 7). An OLS regression model, called the ticket processing model, was used to estimate the relationship between the time spent on each of the four tasks and total tickets processed (Equation 4). The total number of tickets processed per minute (dependent variable) was estimated by the time spent on tasks 1 to 4. Since the time study data only included the total tickets processed per day and the minutes spent by task for that day, it was not possible to attribute the administrative time for each task to a specific ticket.

The model used to estimate the area administrative cost of processing consumer-scale tickets for tasks 1 to 4 (the tickets processed model) was used to derive an estimate of the number of tickets processed per minute for tasks 1 to 4. Table 12 describes the independent variables included in the ticketing process model. For more detail on the SLCLD data utilized for the ticketing process model, see Appendix F.

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1. Stamping and mailing:
- Stamp contract number on each scale ticket booklet
- Write name of buyer on each booklet
- Manually record sale information (contract number, buyer, number of ticket booklets) into a log book
- Send out booklets to buyer

2. Opening and recording tickets:
- Receive and open scale tickets and scale sheets from the consuming mill
- Sort each load ticket and mill scale sheet by contract number
- Manually record the ticket numbers, volume per load, and species under the corresponding contract number in the log book as tickets are

Problem tickets:
- Problem tickets typically arise due to the following reasons:
  *Incomplete/blank scale tickets
  *Completing missing information
  *Checking conflicting information

3. Entering data:
- Enter load ticket information into database
- Once contract is complete, record total volume by species from the log book
- Archive load tickets and scale sheets

4. Closing the sale:
- Complete all paperwork associated with closing a timber sale
- Send information to downtown office for refunding and billing

5. Refunding and billing
- Refund consumer scale sales where the total value scaled is less than the total amount prepaid for the sale
- Bill consumer scale sales where the scaled value exceeds the sale

Figure 7. SLCLD's consumer-scale ticketing process.

Table 11. Ticket processing model independent variables used to estimate the number of tickets processed per minute for Tasks 1-4 within the SLCLD.

Independent variables (Tasks 1-4)	Description
Stamping	Minutes spent stamping and mailing tickets
Opening and recording	Minutes spent opening, sorting and recording
Entering data	Minutes spent entering load ticket information into database
Closing	Minutes spent closing the sale

Using SAS 9.3 (SAS Institute Inc.), Equation 4 was used to estimate the following OLS regression model for the number of tickets processed per minute for tasks 1 to 4:

$$\textbf{Equation 4:} \;\; \text{Tickets processed per minute for tasks 1-4} = \alpha_i + \beta_j x_i + \varepsilon_i$$

The dependent variable is the number of scale tickets processed per minute (excluding task 5: billing and refunds). The x_is in the model represent the number of minutes required to process a ticket for the respective task; β_js are the parameter estimates associated with the ticketing process

tasks, α_i is the intercept, and ε_i is the error term. Model diagnostics (e.g., inspecting the plot of residual and predicted values) suggested a linear model was an appropriate functional form for the SLCLD administrative time data set.

The ticketing process model's F-statistic indicates that the included variables are jointly significant at the 1% level (Table 13). All four variables have a statistically significant influence at the 1% level on the number of tickets processed per minute. The tickets processed model explains approximately 88% of the time required to process scaling tickets. All four variables were statistically significant at the 1% level. The parameter estimate for stamping indicates that approximately 6.59 tickets were stamped and mailed (task one) per minute. The opening and recording parameter estimate suggested that opening and recording (task two) was performed at a rate of approximately 3.75 tickets per minute. Entering data (task three) was performed at a rate of 1.63 tickets per minute, and closing the sale (task four) was performed at a rate of approximately 1.06 tickets per minute. Tasks three and four required the greatest amount of time per ticket, while task one required the least amount of time.

Table 12. Results from the ticketing process model for estimating the number of tickets processed per minute (n= 74 days).

Independent variables[1]	Parameter estimate	S.E.	95% C.I.	
Stamping***	6.59	0.61	5.36	7.81
Opening and recording***	3.75	0.44	2.88	4.62
Entering data***	1.63	0.16	1.31	1.96
Closing***	1.06	0.11	0.83	1.28

Model Fit:
R-square = .8780
Adj. R-square = .8710
F-statistic= 125.87 (Pr < 0.0001)
[1]***=significant at the 1% level

Problem Tickets
Problem tickets occurred intermittently and resulted from a large variety of issues within the ticketing process (e.g., blank/missing scale tickets). These problem tickets were most often addressed by the two SLCLD area administrators, but it is possible for problem tickets to escalate to the supervisor level if the problem required their authority. Consequently, the variation in the minutes spent per problem ticket was wide-ranging. Problem tickets only occurred in tasks two and three, because the issues were generally related to ticket misinformation (e.g., wrong contract number, blank tickets) or problems with retrieving the scale information (e.g., mill does not submit scale information, buyers do not put all lockbox stubs in the lockbox). Because the problem tickets were a subset of ticket processing, it was not possible to estimate the total administrative time in the same manner as tasks 1 to 4.

The administrative time spent on problem tickets was accounted for by separately calculating the estimated time spent on problem tickets each year based on the information obtained from the SLCLD area administrators. The SLCLD area administrators recorded the time spent on problem tickets and number of problem tickets during February and March 2014. To calculate the total problem ticket time, the average number of problem tickets per scale ticket processed was derived during the two-month period (i.e., 0.03 problem tickets per ticket). This percent of problem tickets was multiplied by the total number of tickets processed by the SLCLD in 2014

(11,810 tickets) to obtain an estimate of the number of problem tickets processed annually (384 problem tickets per year). That estimated number of annual problem tickets was then multiplied by the average number of minutes spent per problem ticket (1.12 minutes per problem ticket, as recorded during February and March 2014) to produce the estimated total minutes per year SLCLD spends processing problem tickets (432 minutes [7.2 hours] processing problem tickets per year). Table 14 below illustrates these calculations.

Table 13. Estimated time spent on problem tickets in 2014 based on data provided by the SLCLD.

Problem ticket time recorded during February and March 2014[1]	
Number of problem tickets in February and March. 2014	97
Total minutes spent on problem tickets in February and March 2014	109
Total tickets processed in February and March 2014	2,981
Estimated minutes per problem ticket in February and March 2014[2]	**1.12**
Estimated percent of total tickets that were a problem ticket[3]	**0.03**
Total 2014 problem ticket time	
Total tickets processed in 2014	11,810
Estimated problem tickets[4] **in 2014**	**384**
Estimated problem ticket minutes[5] **in 2014**	**431.8**
Estimated problem ticket hours during 2014	**7.2**

[1] Problem tickets and minutes are taken from February and March 2014 SLCLD administrative time records.
[2] Minutes per problem ticket in February and March 2014 = [problem ticket minutes / number of problem tickets].
[3] Estimated percent of total tickets that were a problem ticket in February and March 2014 = [number of problem tickets / total tickets processed].
[4] Total problem tickets = [estimated percent of total tickets x total tickets processed in 2014].
[5] Total problem ticket minutes = [Total problem tickets x minutes per problem ticket].

Cost Summary of SLCLD Area Administration
To calculate the annual cost of the four area administrative tasks (plus problem tickets), the parameter estimates from Table 13 and the estimated problem ticket time in Table 14 were used to derive an estimate of the total annual minutes spent on each task. As mentioned, the parameter estimates specified that each additional minute spent on an area administrative task produces a certain number of tickets processed. Therefore, the total number of consumer-scale tickets processed in 2014 (i.e., 11,810 tickets) was divided by each parameter estimate to approximate the total minutes spent for each administrative task. Since all scaling tickets go through each of the first four tasks, the total number of tickets processed by SLCLD in 2014 was used to calculate the total annual time spent processing tickets for each task.

After calculating the estimated annual time spent on tasks 1 to 4, the time spent accomplishing those tasks plus the time spent on problem tickets was converted into the number of hours SLCLD spent processing tickets in 2014. Table 15 summarizes the estimated area administrative costs for the consumer-scale ticketing process in St. Louis County.
The results indicate that the estimated annual cost of tasks 1 to 4 and problem tickets to the SLCLD in 2014 was approximately $9,902 based on the $25 (per hour) estimated wage plus benefits. The total number of SLCLD timber sales closed with consumer-scale volume was approximately 94 timber sales in 2014 (33 sales in 2014 designated as SOAV sales), which included blended sales with a majority (50% or more) consumer-scale sale volume. On a per sale basis, this amounts to approximately $105.34 per timber sale (i.e., 4.2 total area administrative hours per consumer-scale sale or blended sale with 50% or more consumer-scale volume). That

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cost was used as a component for calculating an estimate of the total cost of administering a consumer-scale sale by the SLCLD.

Table 14. Estimated scale ticket processing cost within the area office for tasks 1 to 4 and problem tickets within the SLCLD in 2014.

Administrative task	Parameter estimate	Estimated minutes[1]	Estimated hours
Stamping	6.59	1,792.1	29.9
Opening and recording	3.75	3,149.3	52.5
Entering data	1.63	7,245.4	120.8
Closing	1.06	11,141.5	185.7
Problem tickets[2]	-	-	7.2
Total estimated annual ticket processing hours:			396.1
Total 2014 tickets			11,810
Total 2014 consumer-scale and blended sales closed in 2014			94
Estimated administrator salary[3]			$25/hour
Estimated total annual cost[4]			$9,902
Estimated average annual cost (per timber sale)[5]			**$105.34**

[1] Estimated minutes = [total 2014 tickets / parameter estimate from Table 13]
[2] Estimated problem ticket hours from Table 14.
[3] $25 hourly wage plus benefits estimate from USDA Forest Service (FS Job Title: Resource Technician).
[4] Estimated total annual cost = [ticketing process hours x hourly wage].
[5] Estimated average annual cost (per timber sale) = [total cost of the ticketing process / total 2014 consumer-scale and blended sales].

Cost of Downtown Administration: Task 5

Agency staff time is required to bill the buyer for additional funds (overrun occurred) or issue a refund (underrun occurred) for a timber sale once a sale is closed. A sale is considered closed once all blocks have been harvested from a timber tract and the buyer has met all contractual obligations (e.g., harvesting guidelines, silvicultural requirements, appropriate level of utilization), sale volume has been transported to a consumer, all scale tickets have been accounted, or once the timber sale contract has expired. The SLCLD area administrator conducts the sale closure, and then sends the timber sale information to the downtown administrator to bill or refund the buyer. A consumer-scale timber sale often includes refunding or billing the buyers of consumer-scale sales because it is difficult to estimate a priori the volume scaled by species-product. In some instances, the SLCLD does not refund the down payment on SOAV sales until after the final payment has occurred. In these cases, the buyer has paid the full cost of the sale plus the original down payment (e.g., 15% down payment + 100% sale cost = 115% of total sale cost). When there is an overpayment for a SOAV tract in the amount of the down payment, the SLCLD refunds the buyer the amount owed to the buyer.

The administrative time associated with this task was separately analyzed because it is not a part of the consumer-scale ticketing process. The SLCLD downtown administrative time spent billing and refunding timber sales was collected over a seven-week period from March 7, 2014, to April 29, 2014. During this period, the vast majority of the time spent on refunding and billing was associated with consumer-scale timber sales. Before harvesting begins on a tract, buyers pay per unit of merchantable appraised timber on consumer-scale sales, so any discrepancy between the scaled volume and estimated volume sold by the SLCLD was reconciled by the downtown

administrative staff. The consumer-scale cost associated with closing timber sales was calculated by dividing the total minutes spent on consumer-scale sales during the seven week period by the number of consumer-scale sales processed during this same period. When a timber sale is closed, the downtown administrative staff immediately refund or invoice the buyer. Thus, the timber sales closed during the seven-week period in March and April was used to estimate the refunded and billed sales (Table 16) during the year.

There were 21 total sales that closed during the seven-week period (Table 16). The blended sales were apportioned to the timber payment method that had the majority of the timber sale volume (i.e., at least 50% consumer-scale volume was categorized as a consumer-scale sale and at least 50% SOAV was classified as an SOAV sale). There were 15 consumer-scale sales and 6 SOAV sales that closed during this seven-week period. The consumer-scale billing and refunding time on the 15 consumer-scale sales was approximately 8,190 minutes (average of 546 minutes per consumer-scale sale). The time attributed to billing and refunding SOAV sales was called the down payment refund, since it was the time spent refunding buyers their down payment. Similar to the consumer-scale calculation, the total minutes spent refunding down payments during the seven-week period was divided by the number of SOAV sales closed during this seven-week period (6 SOAV sales closed). The estimated time spent on the down payment refund per SOAV sale (140 minutes) is considered a high estimate, since the SLCLD does not use the down payment refund for all SOAV sales. For the purposes of this analysis, it was assumed that the buyers of all 33 SOAV sales closed during 2014 had a down payment refund.

Consumer-scale sales require more time to bill and refund, since SLCLD staff needs to ensure the total payment for a timber sale matches the sale's scaled volume and buyer's bid price per species/product unit harvested. The seven weeks of timber sale billing and refunding data (task 5) provided by the SLCLD was used to calculate the annualized hours spent on billing and refunding consumer-scale sales and refunding down payments on SOAV sales. The estimated cost of the 94 consumer-scale sales closed in 2014 was approximately $227.39 per timber sale, whereas the estimated cost for refunding the down payment on the 33 SOAV sales in 2014 was approximately $58.33 per timber sale based on $25 (per hour) estimated wage plus benefits (Table 16). Thus, the total estimated annual cost of closing all 94 consumer-scale and 33 SOAV timber sales in 2014 was $21,375 and $1,925 per year, respectively. These costs were used in section 3.4 to calculate the total cost of the SLCLD consumer-scale ticketing process (i.e., tasks 1 to 5).

The estimated time spent billing and refunding each timber sale is considered a high estimate, and it is likely an attribute of the specific downtown administrator that recorded the time. The SLCLD staff noted that administering the billing and refunding consumer-scale sales should take about one hour; however, the analysis uses the estimated administrative times, since it is the actual cost to the SLCLD.

Table 15. Estimated timber sale costs for billing and refunding (task 5) within the SLCLD in 2014.

Administrator time recorded during March and April, 2014	
Total minutes[1] in March and April 2014 by payment method	
Consumer scale	8,190
Down payment refund[2] (only applied to SOAV)	840
Total timber sales[3] closed during March and April, 2014 by payment method	
Consumer scale	15
Down payment refund	6
Estimated average minutes per sale[4] by payment method	
Consumer scale	546
Down payment refund	140
Total timber sales closed in 2014[5]	
Consumer scale[6]	94
SOAV[7]	33
Estimated total annual minutes in 2014[8]	
Consumer scale	51,324
Down payment refund	4,620
Estimated annual hours in 2014 by payment method	
Consumer scale	855
Down payment refund	77
Estimated administrator annual salary	$ 25/hour
Estimated total annual billing and refunding cost in 2014 by payment method	
Consumer scale	$21,375
Down payment refund	$1,925
Total cost of closing timber sales	**$23,300**
Estimated average billing and refunding cost (per timber sale) in 2014 by payment method	
Consumer scale	**$227.39**
Down payment refund	**$58.33**

[1] The consumer-scale and SOAV minutes for the seven-week period in March and April, 2014 were recorded by the SLCLD downtown timber sale administrator.

[2] The down payment refund was the time spent refunding SOAV sales in task 5.

[3] Consumer-scale sales and SOAV sales are the number of SLCLD sales closed during the seven-week period in March and April, 2014. After a sale is closed the billing and refunding task occurs.

[4] Estimated minutes per sale = [total minutes / total sales] during the seven-week period in March and April 2014.

[5] Total sales in 2014 include all closed sales.

[6] The 94 consumer-scale sales closed in 2014 included 100% consumer-scale sales and blended sales with at least a majority (50% or more) of consumer-scale volume.

[7] The 33 SOAV sales in 2014 included 23 100% SOAV sales and 10 blended sales with a majority (more than 50%) of SOAV volume.

[8] Estimated minutes in 2014 = [minutes per sale x total sales in 2014].

Cost Summary of Administering the Ticket Processing: Tasks 1-5

The total estimated costs for the SLCLD consumer-scale ticketing process are the combined results of the ticketing process and the billing and refunding cost analyses (i.e., Tables 16 and 17). The total material cost for printing tickets of 9.5 cents per ticket (Jason Meyer of SLCLD, personal communication, September 12, 2014) was also incorporated into the consumer-scale ticketing calculation (Table 17). The estimated average costs of ticket processing were included in the Chapter Summary (section 3.4) to evaluate the estimated cost differences between the two timber payment methods. Those costs represent direct financial outlays for each payment method.

Table 16. Estimated annual and average costs of the ticketing process for consumer-scale and SOAV timber sales within the SLCLD in 2014.

Estimated annual consumer-scale timber sale cost of ticket processing[1]	
Area administration (Tasks 1-4 and problem tickets)	$ 9,902
Downtown administration (Task 5)	$ 21,375
Printing cost[2]	$ 1,122
Total estimated annual consumer-scale cost of ticket processing	$ 32,399
Estimated consumer-scale cost of ticket processing per timber sale[3]	
Area administration (Tasks 1-4 and problem tickets)	$105.34
Downtown administration (Task 5)	$227.39
Printing cost	$11.93
Total estimated average cost of ticket processing per timber sale	**$344.66**
Estimated total annual cost	
Down payment refund	$ 1,925
Estimated cost per SOAV timber sale	**$ 58.33**
Down payment refund[4]	

[1] Administrative cost information taken from Tables 16 and 17.
[2] Printing cost per consumer-scale ticket is 9.5 cents, and the total tickets processed in 2014 are 11,810. Printing cost = [9.5 cents x 11,810 tickets processed in 2014= $1,122].
[3] There were 94 consumer-scale and blended sales that closed in 2014 which utilized the ticketing process.
[4] Down payment refund cost information taken from Table 16.

The consumer-scale ticketing costs reported in Table 17 identify the cost of timber sales with a majority (at least 50%) of consumer-scale sale volume. Sales with a majority (more than 50%) of SOAV sale volume only require administrative staff time for the down payment refund; therefore, the consumer-scale ticketing process and the down payment refund for SOAV sales were direct financial outlays for each payment method.

3.3. Cost of In-woods Agency Scaling of Harvested Timber

The time spent by an agency to scale in-woods volume which is not going to a mill (e.g., firewood going to a homeowner) or is going to a mill that does not have a consumer-scale agreement with SLCLD (e.g., a small sawmill) is an operating cost which is only incurred on consumer-scale sales. In-woods agency scaling is when the seller manually scales volume on a consumer-scale sale. In these situations, SLCLD staff measure the length and diameter of individual sawlogs or the height, width, and length of piled timber to calculate total volume. In 2014, approximately 95% of SLCLD's volume was scaled by the consuming mill (Appendix G), and the remaining 5% of SLCLD consumer-scale volume was scaled by SLCLD staff (Jason Meyer, personal communication, April 3, 2015).

Agency scaling time was calculated by taking an approximate time spent scaling each cord and multiplying that time by the total agency scaled volume of 6,904 cords in 2014 (Jason Meyer, personal communication, April 3, 2015). Four SLCLD and MN DNR foresters were contacted to provide an estimate of the time spent on in-woods agency scaling. They estimated that it takes between 30 seconds and 1.5 minutes to manually scale each cord of timber; therefore, the intervals of 30 seconds, 1 minute, and 1.5 minutes were used to estimate the administrative time spent on annual in-woods agency scaling (Table 18). The estimated time was then converted into estimated total and average costs for in-woods agency scaling (Table 19). The $30/hour wage

level and benefits used for the analysis was based on salary ranges for equivalent positions with the USDA-Forest Service as stated in recent notices for similar positions. This approximate level of salary and benefits for county foresters conducting the in-woods agency scaling was verified by SLCLD managers. The estimated range of total annual costs was between $1,725 and $5,178, and the estimated range of average cost per timber sale was $18.35 to $55.09 (Table 19).

Table 17. Estimated time spent annually on in-woods agency scaling for consumer-scale sales by the SLCLD in 2014.

Estimated annual time	Lower estimate[1]	Middle estimate[2]	Upper estimate[3]
Total estimated minutes[4]	3,452	6,904	10,356
Total estimated hours[5]	57.5	115.1	172.6

[1] Lower estimate was based on 30 seconds per cord.
[2] Middle estimate was 1 minute per cord.
[3] Upper estimate was 1.5 minutes per cord.
[4] Average estimated minutes based on the 6,904 cords that were agency scaled in 2014.
[5] Average estimated hours = [lower/middle/upper estimate in minutes / 60 minutes]

Table 18. Total annual and average estimated costs per timber sale of in-woods agency scaling for the SLCLD in 2014 under three cost estimates (consumer-scale sales only)[1],

Agency annual scaling hours (Table 18)	
Lower estimate	57.5
Middle estimate	115.1
Upper estimate	172.6
Estimated hourly salary and benefits[2]	$30/hour
Total estimated annual cost	
Lower estimate	$ 1,725
Middle estimate	$ 3,453
Upper estimate	$ 5,178
Estimated average cost per timber sale[3]:	
Lower estimate	$18.35
Middle estimate	$36.73
Upper estimate	$55.09

[1] SOAV sales do not utilize in-woods agency scaling and thus were excluded from this analysis.
[2] $30 hourly wage including benefits estimate from USDA Forest Service (FS Job Title: Forestry Technician).
[3] There were 94 sales which closed in 2014 with majority consumer-scale sale volume in 2014. Each estimated average = [total estimated cost /94 consumer-scale sales].

3.4. Chapter Summary

Chapter 3 evaluated the three major cost factors that were expected to influence the total cost of each payment method. These include the timber cruising (section 3.1), ticketing process (section 3.2), and in-woods agency scaling (section 3.3). The hypothesis (section 1.3) theorized that the consumer-scale payment method is more costly due to the additional cost of processing scale tickets. While the hypothesis on total cost differences was correctly postulated, the analysis also found that in-woods agency scaling, printing costs, and the down payment refund on SOAV sales also influenced the total cost differences between payment methods. The assessment found that

the average consumer-scale timber sale was approximately \$323.06 more expensive to administer than the average SOAV timber sale (Table 20).

Table 19. Summary of average estimated costs differences between the consumer-scale and SOAV timber payment methods in the SLCLD in 2014.

Estimated average consumer-scale sale cost per timber sale[1]	
Area administration (task 1-4 and problem tickets)	\$105.34
Downtown administration (task 5)	\$227.39
Printing cost	\$11.93
In-woods agency scaling[2]	<u>\$36.73</u>
Estimated total average cost per timber sale	**\$381.39**
Estimated average SOAV sale cost per timber sale[2]	
Down payment refund	<u>\$58.33</u>
Estimated total average cost per timber sale	**\$58.33**
Estimated total cost difference between payment methods (Consumer Scale – SOAV) per timber sale	**\$323.06**

[1]Estimated average consumer-scale costs from Tables 18 and 20.
[2]Estimated average SOAV sale cost from Table 17.

4. Cost-effectiveness Summary

The objective of this study was to assess how timber payment method impacted the cost-effectiveness of timber sale programs administered by the SLCLD. To evaluate cost-effectiveness, the study analyzed the net timber sale revenue for SOAV and consumer-scale payment methods (gross timber sale revenue minus total administrative costs), which highlights the financial tradeoffs between each timber payment method. The assessment utilized the findings from Chapter 2 and 3 to the test the study's hypotheses of timber payment method's impact on a timber sale program's cost-effectiveness.

4.1. Gross Timber Sale Revenue Differences

This research tested the null hypothesis that there are no differences in gross timber sale revenue attributed to the timber payment method. The hypothesis was based on previous literature (Kueper et al., 2014; Kilgore and Blinn, 2005; Flick, 1985; Maroaka and Watson, 1983, 1986; Deckard et al., 2011) and anecdotal evidence that suggested timber payment method influences gross timber sale revenue. The hypothesis was that SOAV sales would generate higher gross timber sale revenue due to the increased utilization of merchantable volume.

The gross timber sale revenue model, the winning bid value model, and the paired bidding experiment all failed to reject the null hypothesis that there are no differences in gross timber sale revenue attributed to timber payment method; therefore, timber payment method has no marginal effect on gross timber sale revenue. In the cost-effectiveness analysis, total SLCLD administrative costs are subtracted from gross timber sale revenue for each payment method (Equation 5). Because there are no differences in gross timber sale revenue between the two payment methods, the timber payment method can only influence the net timber sale revenue of a public timber sale program through total administrative costs.

Equation 5: Net timber sale revenue = gross timber sale revenue – total administrative costs

4.2. Total Administrative Cost Differences

The total administrative cost assessment in Chapter 3 confirmed the hypothesis that timber payment method created differences in the total costs of the two payment methods. Similar to the gross timber sale revenue analysis, the results from Chapter 3 were derived from data obtained from the SLCLD. The cost analyses estimated the average and total costs of timber cruising, the ticketing process, and in-woods agency scaling for both payment methods in the SLCLD. Table 20 presents picture summary of the SLCLD timber program's cost-effectiveness, which summarizes the estimated costs of administering SOAV and consumer-scale payment methods.

The results indicate that each consumer-scale sale costs approximately $323.06 more than a comparable SOAV sale for an SLCLD timber sale. Since gross timber sale revenue equaled zero in Equation 5, the consumer-scale timber payment method was less cost-effective than the SOAV timber payment method by approximately $323.06 per timber sale. The average estimated cost differences of the SLCLD timber sale program (Table 20) were used in the Chapter 5 sensitivity analysis to explore cost-effectiveness scenarios of the two payment methods in other agency timber sale programs, since there were no gross timber sale revenue differences between payment methods.

5. Sensitivity Analysis

The focus of the analysis and summary in Sections 2 to 4 has been on the SLCLD. To assess how payment methods might impact the cost effectiveness of organizations with different cost structures (e.g., a higher wage rate), a sensitivity analysis was conducted. The sensitivity analysis evaluates how timber payment method's influence on the cost-effectiveness of timber sale programs might vary between public timber sale programs. The analysis explores several cost scenarios, based on the SLCLD timber program costs, to evaluate how the total administrative cost might differ in other timber programs. The sensitivity analysis did not evaluate gross timber sale revenue, since the analyses in Chapter 2 found that timber payment method had no influence on gross timber sale revenue. Public agencies have slightly different cost structures as a result of distinct timber sale procedures (e.g., timber cruising standards) and administrative cost efficiencies (i.e., low and high cost ticketing processes). To compare different timber sale programs, the sensitivity analysis explores four cost scenarios that are based on the estimated costs of the SLCLD timber program.

The results from the average estimated cost analysis of the SLCLD timber program (Table 20) are utilized to create a baseline cost scenario by which to assess the four other cost scenarios. However, it is also necessary to understand the average cost of timber cruising per SLCLD timber sale in order to provide information for a review of timber payment methods under multiple cost scenarios. Since many public timber programs have different timber cruising standards between timber payment methods (e.g., more administrative time timber cruising SOAV sales), the SLCLD's cost of timber cruising for both payment methods is estimated in section 5.1 to obtain an approximate timber cruising cost for a timber sale. The estimated cost of timber cruising is used in the sensitivity analysis in section 5.2.

5.1. Cost of Timber Cruising

As noted in section 3.1, the SLCLD does not use different timber volume accuracy standards for appraising SOAV and consumer-scale timber sales. The standard for timber cruising both SOAV and consumer-scale sales in the SLCLD is a ±20% appraisal error for "major species" and a ±15% appraisal error for all species combined (Jason Meyer of the SLCLD, personal communication, 2014). However, many public timber sale programs have a higher standard for timber cruising SOAV sales as compared to consumer-scale sales to reduce the risk of underestimating timber volume (section 1.1). For example, the MN DNR's timber sale cruising standard for consumer-scale sales is ±20% volume accuracy and for SOAV sales is ±10% volume accuracy (Deckard et al., 2011). In order to assess timber programs that have different timber cruising standards, the average timber cruising cost per SLCLD timber sale is estimated to illustrate distinct timber cruising standards used by other public agencies.

The SLCLD does not collect separate information for time spent timber cruising SOAV and consumer-scale sales, but the cost of timber cruising was able to be estimated because the SLCLD spends the same amount of administrative time for both payment methods. To calculate the estimated timber cruising time, information was gathered from SLCLD staff on the total annual sample plots and the total annual appraised acres from 2008-2014 (Appendix H, Chart 1). To determine the characteristics of a tract, sample plots are established by foresters to determine the species present and the volume by species and product category (e.g., pulpwood, bolts, sawtimber) within the plot. Sample plots are well-distributed throughout the timber stand to obtain a representative sample of the diversity of timber present. The average annual number of plots taken by the SLCLD from 2008 to 2014 was 8,046 (Appendix H, Chart 1) (Tom Zeisler of the SLCLD, personal communication, April 8, 2015). Four experienced foresters from the SLCLD and MN DNR were interviewed to understand the time spent taking each plot and the time spent walking between plots (i.e., intraplot travel time). The foresters indicated that the time spent collecting data within a plot ranges from 30 seconds to 10 minutes, depending on the stand's density and condition. Higher density stands and stands with more valuable timber require more time to estimate the larger volumes on each acre, and the condition of standing and dead trees also affects the total time spent per plot.

A range of plot sample times of 3, 5, and 7 minutes were created for the total estimated plot time. In addition, the foresters who were contacted indicated the estimated time spent traveling between each plot varies depending on the terrain. The interviewees said that the intra-plot travel time ranged from 3 to 5 minutes, so a range of intraplot travel time of 3, 4, and 5 minutes was created to estimate the total estimated intraplot travel time. The plot and intraplot travel times (Appendix H, Chart 4) were combined to estimate a range of timber cruising administrative time per year (Table 21). The estimated timber cruising time was subsequently converted into a total annual cost by using an approximate hourly wage plus fringe of $30 per hour. The wage level used for the analysis was based on salary ranges for equivalent positions with the USDA-Forest Service as stated in recent job notices for similar positions. This approximate level of salary and benefits was verified by SLCLD managers.

The estimated range of total timber sale cruising costs per year is $24,138 to $48,273, and the estimated range of average timber sale cruising costs is $190.1 to $380.10 per sale (Table 21).

For the purposes of the sensitivity analysis, the timber cruising middle estimate was utilized for the SLCLD baseline cost scenario to compare timber programs with different timber cruising standards. The middle estimate is expected to be a conservative approximation, since there are other costs associated with timber cruising that are not captured in the time estimates (e.g., drive time to harvesting site to collect scale tickets).The estimated average cost of timber cruising per SLCLD timber sale is $285.09 (Table 21).

Table 20. Total and average estimated costs of timber cruising in the SLCLD during 2014[5].

Estimated annual timber cruising hours[1]	
Lower estimate (6 minutes per plot)[2]	804.6
Middle estimate (9 minutes per plot)	1,206.9
Upper estimate (12 minutes per plot)	1,609.1
Estimated forester salary[3]:	$30/hour
Estimated annual range of total timber cruising costs[4]	
Lower estimate	$ 24,138
Middle estimate	$ 36,207
Upper estimate	$ 48,273
Estimated range of average timber cruising costs (per sale[4]):	
Lower estimate	$ 190.06
Middle estimate	$ 285.09
Upper estimate	$ 380.10

[1] Estimated timber cruising hours is the total estimated hours spent on all sales in 2014 (i.e., SOAV and consumer scale).
[2] Lower, middle, and upper estimates represent the combined plot and intra-plot travel times from Charts 2 and 3 in Appendix H.
[3]$30 hourly wage plus benefits estimate from USDA Forest Service (FS Job Title: Forestry Technician).
[4]There were 127 total sales in 2014 (i.e., SOAV, consumer-scale, and blended sales).
[5]*Source*: Tom Zeisler of the SLCLD, personal communication, April 8, 2015.

5.2. Results

The SLCLD costs for administering two payments methods were calculated based on the estimated average costs of the ticketing process (section 3.2), in-woods agency scaling (section 3.3), and timber cruising (middle cost estimate) (Table 21). These costs are used as a baseline by which to compare other cost scenarios. Therefore, the baseline scenario illustrates the cost per sale by payment method in the SLCLD during 2014. As discussed in section 3.1, the cost difference for timber cruising between SOAV and consumer-scale timber payment methods is zero (i.e., $285.09 timber cruise administrative cost per sale for both timber payment methods), since the SLCLD does not differentiate their appraisal standards between timber payment methods. Table 22 includes the $285.09 as a cost item for both timber payment methods to illustrate that there is a timber cruising cost; however, there are no administrative cost differences created by the SLCLD's timber cruising.

Table 21. Estimated cost per timber sale for cruising (appraising) a timber sale, the ticketing process, and in-woods scaling for the SLCLD in 2014.

Consumer-scale method ($ per timber sale)	
Estimated average cost of timber cruising[2]	$285.09
Estimated average cost the ticketing process[1]	$344.53
Estimated average cost of in-woods agency scaling[3]	$36.73
Estimated average cost per consumer-scale sale	$666.35
SOAV method ($ per timber sale)	
Estimated average cost of timber cruising	$285.09
Estimated average cost of the ticketing process	$0.00
Estimated average cost of the down payment refund[4]	$58.33
Estimated average cost per SOAV sale	$343.42
Estimated total cost difference	**$323.06**

[1] Estimated average cost of the ticketing process is taken from Table 17.
[2] Estimated average timber cruising cost is taken from Table 21.
[3] Estimated average cost of in-woods agency scaling is based on the middle estimate from Table 19.
[4] Estimated average cost of the down payment refund is taken from Table 17.

The SLCLD's estimated administrative cost per consumer-scale and SOAV sale is approximately $666.36 and $343.43, respectively (Table 22). The difference between the two estimated average costs per timber sale is the total cost difference between payment methods in the SLCLD, which is approximately $323.06 higher for timber sales using the consumer-scale timber payment method.

The sensitivity analysis uses the SLCLD administrative costs (Table 22) to generate cost estimates of the two timber payment methods for other timber programs. The cost scenarios do not fully encapsulate the variety of cost structures of timber payment method administration for all public agencies; however, they illustrate possible cost-effectiveness scenarios for a range of timber programs, including the MN DNR.

The MN DNR cost scenario is provided to evaluate the total administrative cost differences under program-specific assumptions. Deckard et al. (2011) indicated that the MN DNR's timber sale cruising standard for consumer-scale sales is ±20% volume accuracy, which is the timber cruising standard the SLCLD uses for all "major species". Therefore, the sensitivity analysis assumes that the MN DNR's consumer-scale timber cruising cost is equal to the SLCLD timber cruising cost (i.e., $285.09). Deckard et al. (2011) also specified that MN DNR timber sales require about twice the administrative time for timber cruising SOAV sales compared to consumer-scale sales, so the MN DNR cost scenario has a timber cruising cost for SOAV sales equal to twice the SLCLD baseline cost. In addition, the MN DNR has a ticketing process for SOAV sales. Since the SOAV timber payment method does not include billing and refunding (task 5), the estimated cost of the ticketing process for SOAV sales was reduced by two-thirds ($227.39 per sale [Table 20]) to account for this cost savings. The MN DNR cost scenario does not include a cost for the down payment refund of SOAV sales, and it assumes the in-woods scaling cost is equal to the SLCLD baseline cost.

The following illustrates the assumptions for each of the four cost scenarios.

1. Different timber cruising standard
    a. The timber cruising cost for SOAV sales is twice (2.0x) the SLCLD baseline cost.
    b. The timber cruising cost for consumer-scale sales is equal (1.0x) to the SLCLD baseline cost.
2. High cost consumer-scale scenario
    a. The ticketing process cost for consumer-scale sales is twice (2.0x) the SLCLD baseline cost.
    b. The ticketing process cost for SOAV sales is zero.
3. Low cost consumer-scale scenario
    a. The ticketing process cost for consumer-scale sales is half (0.5x) the SLCLD baseline cost.
    b. The ticketing process cost for SOAV sales is zero.
4. MN DNR scenario
    a. The ticketing process cost for consumer-scale sales is equal (1.0x) to the SLCLD baseline cost.
    b. The ticketing process cost for SOAV sales is one-third (0.34x) the SLCLD baseline cost.
    c. The timber cruising cost for consumer-scale sales is equal (1.0x) to the SLCLD baseline cost.
    d. The timber cruising cost for SOAV sales is twice (2.0x) to the SLCLD baseline cost.
    e. The down payment refund costs for SOAV sales equals zero.

The results of the sensitivity analysis (Table 23) indicate that three of the four scenarios yield a higher total administrative cost for timber sales using the consumer-scale timber payment method. The SLCLD baseline scenario's total administrative cost is $323.06 higher per sale for the consumer-scale timber payment method, which is primarily driven by the ticketing process. The different timber cruising standards scenario's total administrative costs is $37.84 higher per sale for the consumer-scale timber payment method, which is associated with higher cost timber cruising on SOAV sales. The high cost consumer-scale scenario's total administrative cost is $666.46 higher per sale for the consumer-scale timber payment method, which is attributed to a less efficient (more costly) ticketing process. The low cost consumer-scale scenario's total administrative cost is $150.61 higher per sale for the consumer-scale timber payment method, which is due to a more efficient (less costly) ticketing process. The MN DNR cost scenario's total administrative cost is $20.97 higher per sale for the SOAV timber payment method, which is attributed to higher timber cruising cost on SOAV sales, a ticketing process cost for both payment methods, and zero cost for the down payment refund. Figure 8 below illustrates the total administrative cost differences per timber sale (consumer scale – SOAV) for the SLCLD and the four cost scenarios.

Table 22. Sensitivity analysis to estimate the total cost differences per timber sale between payment methods under four scenarios.

Payment method	Cost Scenarios[1]			
	Different timber cruising standards[2]	High cost consumer scale[3]	Low cost consumer scale[4]	MN DNR[5]
Consumer-scale timber sales (per timber sale)				
Estimated average cost of timber cruising[6]	285.09	285.09	285.09	285.09
Estimated average cost of the ticketing process	344.53	689.06	172.27	344.53
Estimated average cost of in-woods agency scaling[7]	36.73	36.73	36.73	36.73
Estimated average cost per consumer-scale sale	$666.35	$1,010.88	$494.09	$666.35
SOAV timber sales (per timber sale)				
Estimated average cost of timber cruising	570.18	285.09	285.09	570.18
Estimated average cost of the ticketing process	0.00	0.00	0.00	117.14
Estimated average cost of down payment refund	58.33	58.33	58.33	0.00
Estimated average cost per SOAV sale	$628.51	$343.42	$343.42	$687.32
Total cost difference per sale (consumer scale – SOAV)	**$37.84**	**$666.46**	**$150.67**	**-$20.97**

[1] All cost scenarios based on the estimated costs of the SLCLD timber program from Table 22.
[2] Different timber cruising standards have 2.0x the timber cruising cost for SOAV sales.
[3] High cost consumer scale has 2.0x the cost of the ticketing process.
[4] Low cost consumer scale has 0.5x the cost of the ticketing process.
[5] MN DNR have 2.0x the timber cruising cost and 0.34x the ticketing process cost for SOAV sales.
[6] Estimated average cost of timber cruising utilized the middle estimated figure (i.e., 9 minutes per plot) from Table 21.
[7] Estimated average cost of in-woods agency scaling cost utilized the middle estimated figure (i.e., 1 minute per cord) from Table 18.
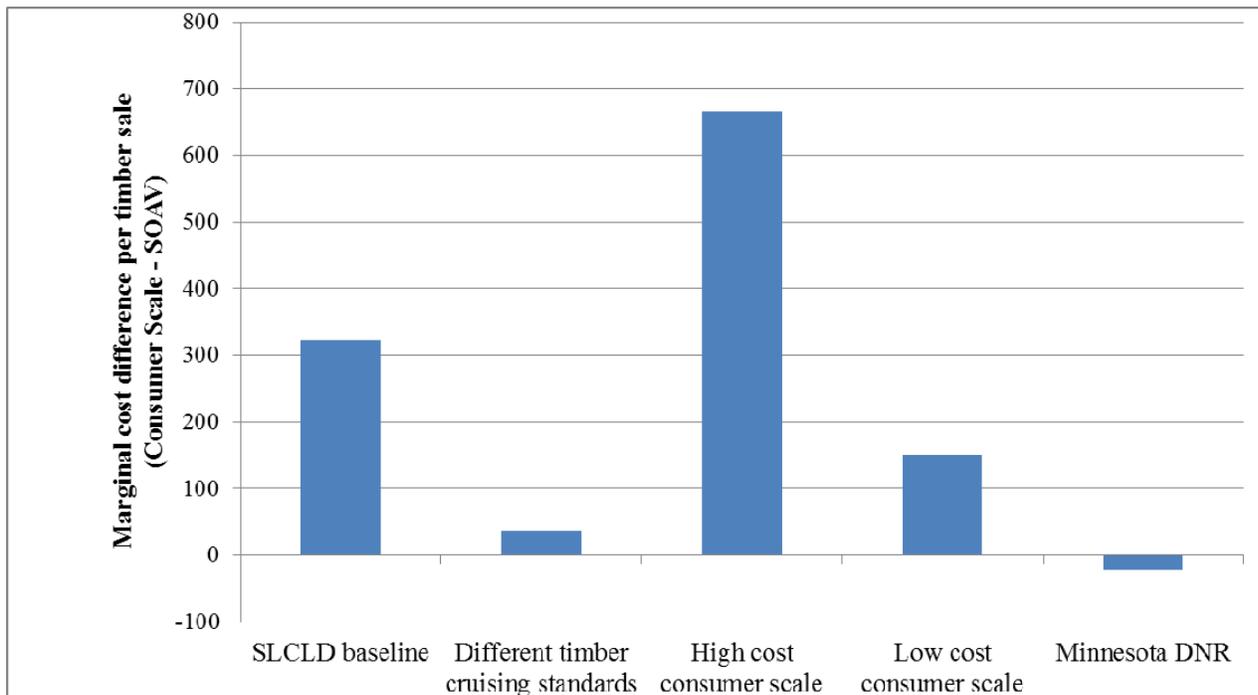

Figure 8. Estimated total administrative cost differences ($ per timber sale) (consumer scale minus SOAV) for the SLCLD and the four cost scenarios from the sensitivity analysis.

6. Summary and Conclusions

The main objective of this study was to assess how timber payment method impacts the cost-effectiveness of the timber sale programs administered by the SLCLD in Minnesota. The study assessed the differences in gross timber sale revenue and total administrative costs to estimate the financial tradeoffs associated with implementing each timber payment method on SLCLD timber sales. The study's important findings are (1) timber payment method does not influence gross timber sale revenue on SLCLD timber sales and (2) the total administrative cost differences between the two timber payment methods are relatively small on SLCLD timber sales.

Prior research found that the impact of the timber payment method on gross timber sale revenue from public timber sales varies widely. Several studies (Flick, 1985; Maroaka and Watson, 1983, 1986) theorized that the SOAV timber payment method produced higher bid values (i.e., WTP for timber). Conversely, Deckard et al. (2011) found that SOAV bid values were discounted by 5-15% compared to bids submitted for consumer-scale sales to account for the increased risk of volume underruns. These contradictory findings were also highlighted in the national review of MN DNR timber sale programs by Brown et al. (2010). The authors discussed the findings from a focus group of various state timber program supervisors, and there was very little agreement amongst those supervisors related to the influence of timber payment method on stumpage prices. The MN DNR supervisors claimed that timber purchasers often have personal preferences for timber payment method which influences their WTP for timber. One MN DNR supervisor indicated that timber purchasers have higher bid values on SOAV sales due to their ability to merchandize more timber volume. On the other hand, Brown et al. (2010) also pointed out that buyers sometimes prefer the consumer-scale method because they do not have to incur as much risk when bidding for a tract of timber.

Chapter 2 used a three-part analysis to assess how timber payment method influences gross timber sale revenue. It was theorized that timber payment method created differences in gross timber sale revenue because buyers could merchandize more timber volume on SOAV sales, which might influence their WTP for timber. The hypothesis was based on the notion that the stumpage cost of an SOAV timber sale is fixed regardless of the volume removed. Therefore, buyers might be incentivized to utilize more merchantable volume on an SOAV timber sale as compared to a consumer-scale sale. Buyers might not utilize some material from the consumer-scale sales if the marginal cost of harvesting trees, or sections of trees, exceeds the marginal revenue; whereas the SOAV method might drive utilization higher, as any revenue received for additional stumpage (i.e., volume harvested above the appraised cords) represents lower production costs since the additional units have no stumpage cost.

The hypothesis of timber payment method's impact on gross timber sale revenue was tested in the gross timber sale revenue model (section 2.1). The model was designed to evaluate whether timber payment method influenced overall gross timber sale revenue per acre. Gross timber sale revenue is comprised of two components, WTP for timber and merchantable volume (Equation 1). Because the potential to increase the utilization on SOAV sales might also influence a buyer's WTP (i.e., create a premium for the SOAV payment method), the study also sought to understand how the two components influenced overall gross timber sale revenue. The second

hedonic price model, the winning bid value model (section 2.2), was developed to evaluate WTP for timber. The paired bidding experiment (section 2.3) was also used to assess timber payment method's influence on WTP for timber.

The gross timber sale revenue model failed to reject the null hypothesis that there was no difference in gross timber sale revenue attributed to timber payment method (section 2.1). The winning bid value model and the paired bidding experiment also failed to reject the null hypothesis that there was no difference in WTP for timber attributed to timber payment method (sections 2.2 and 2.3). As shown in Equation 1, gross timber sale revenue equals WTP for timber multiplied by merchantable volume. Because timber payment method was found to have no influence on gross timber sale revenue and WTP for timber, the analysis holds that timber payment method does not influence scaled volume (Equation 1).

This was the first empirical assessment of timber payment method's influence on gross timber sale revenue, and it presents a distinct position in the discussion on timber payment method's influence on WTP for timber. Previous studies found that timber payment method produced both a premium (Flick, 1985; Maroaka and Watson, 1983, 1986) and a discount (Deckard et al. 2011) on WTP for timber; however, this study found that timber payment method has no influence on WTP for timber. Since there were no differences in WTP for timber between payment methods, buyers of SLCLD timber sales were not likely expecting higher utilization on SOAV tracts, as they were not submitting higher bids on SOAV timber volume. In addition, buyers were not likely harvesting more volume on SOAV sales, since timber payment method was not found to influence merchantable volume.

Chapter 3 analyzed the administrative cost differences between SOAV and consumer-scale payment methods. The major cost differences between timber payment methods in the SLCLD are the administrative resources spent on the consumer-scale ticketing system and in-woods agency scaling. The SLCLD uses the same resources on timber cruising SOAV and consumer-scale sales, so this is not a driver of administrative cost differences for the SLCLD; however, it is a cost difference for other public agencies, which is discussed in the sensitivity analysis (section 5.2). It was hypothesized that the consumer-scale timber payment method was more costly compared to the SOAV timber payment method due to the consumer-scale ticketing system.

Previous studies that discussed administrative costs related to the two timber payment methods also varied. Brown et al. (2010) found that state supervisors believe that SOAV sales have lower administrative costs, since the SOAV payment method does not require a ticketing process. On the other hand, Deckard et al. (2011) asserted that the SOAV timber payment method had higher administrative costs, and the authors attributed the increased cost to the increased administrative time spent timber cruising SOAV sales. The Deckard et al. (2011) report analyzed the MN DNR timber program, which has different timber cruising standards for SOAV and consumer-scale sales. Since the SLCLD was the focus of this analysis, and they do not use different timber cruising standards between timber payment methods, it was hypothesized that the consumer-scale timber payment method would be more costly due to the increased cost of the ticketing process.

As described in Chapter 3, the total administrative cost difference between timber payment methods is approximately $323.06 more for each consumer-scale sale (Table 22). As hypothesized, the estimated total administrative cost difference for the SLCLD was primarily driven by the increased cost of administering a timber ticketing process. The total annual cost of the SLCLD's consumer-scale payment method was approximately $37,765 higher than the SOAV payment method (total annual cost estimates of ticket processing was $32,399 [Table 17] and in-woods scaling was $3,453 [Table 19]). The SLCLD timber sale dataset used in Chapter 2 indicated that the average gross timber sale revenue per timber sale was approximately $41,632. Annual timber sales in the SLCLD generally exceed 100 sales (127 timber sales in 2014), so the total cost of the consumer-scale system is relatively small (i.e., less than average gross timber sale revenue of one timber sale), compared to the annual gross timber sale revenue per year by the SLCLD.

St. Louis County is the largest county in Minnesota (Figure 2), managing approximately 639,400 acres of commercial forest (St. Louis County Land Department, 2015). SLCLD conducts approximately four timber auctions per year (i.e., one per quarter), which amounts to about 100 timber tracts sold annually. In addition, the SLCLD sells timber stumpage on approximately 10,000 acres (i.e., 200,000 cords) annually (St. Louis County Land Department, 2015), which is considered a relatively large public timber agency. The MN DNR offers on average 800,000 cords of timber annually, and they are one of the largest state timber agencies in the United States (Brown et al., 2010). According to the public stumpage and price review, in 2014 the MN DNR and SLCLD generated approximately $22.9 and $5.0 million in stumpage revenue (MN DNR - Forests, 2014), respectively, which illustrates that the SLCLD is about one-fourth the size of the MN DNR. Therefore, the additional annual cost of administering the consumer-scale payment method system ($37,765) pales in comparison with the total gross timber sale revenue per year ($5.5 million) by the SLCLD. Therefore, the additional cost of consumer-scale administration is approximately 0.75% of total annual gross timber sale revenue for the SLCLD.

The sensitivity analysis carried out in Chapter 5 utilized the cost-effectiveness summary from Chapter 4 to approximate the total administrative cost differences of lower and higher cost timber programs, using the cost of the SLCLD's timber program as a baseline cost scenario (Table 22). The analysis found that the consumer-scale timber payment method was more costly to administer in the SLCLD baseline scenario and the four cost scenarios: different timber cruising standards, high cost consumer scale, low cost consumer scale, and MN DNR. While the sensitivity analysis did not encapsulate the different cost structures of every timber program, it illustrated that the consumer-scale payment method was generally more expensive to administer than the SOAV timber payment method. However, even under the high cost consumer-scale scenario (more costly ticketing process), the total cost of consumer-scale administration was only $666.46 higher per consumer-scale sale (Table 23).

Despite the fact that the total annual cost of the consumer-scale system is relatively small compared to the total annual gross timber sale revenue generated by the SLCLD, there are still cost efficiencies to be gained. Chapter 2 found that timber payment method created no differences in gross timber sale revenue per acre, so improving the overall cost-effectiveness of the timber payment method for the SLCLD is related to reducing the total cost of the consumer-scale system.

Two potential cost savings include the implementation of a less expensive (i.e., more cost efficient) ticket processing system on consumer-scale sales and using the SOAV payment method for more remote timber sales. The largest expense of the consumer-scale payment method in the SLCLD is ticket processing consumer-scale tickets, which costs approximately $32,399 per year. Processing tickets requires the coordination of several administrators to ensure that all scaled volume information on consumer-scale sales is collected and the refunds or billings are submitted to the buyers. Reducing the cost of ticketing administration could occur through the implementation of a new system to track harvested volumes on consumer-scale sales that is more advanced (or less costly). A second potential efficiency gain is to utilize the SOAV payment method on remote timber sales, since consumer-scale sales might require the agency to travel to and from the harvesting site to set up the scale ticket dropbox and to collect scale tickets once a sale closes. The additional cost of traveling on consumer-scale sales was not included in Chapter 3's cost analysis, because the information was not available.

Prior to this study, there was very little empirical research available on timber payment method's influence on gross timber sale revenue or the total cost of administering each payment method. Therefore, the analysis provides a better understanding of the financial tradeoffs between the payment methods so that Minnesota's public timber sale programs may be enhanced. While there are nonfinancial tradeoffs (e.g., ecological, social, and political) between timber payment methods, the focus of this study was on the financial tradeoffs between payment methods, which were found to be relatively insignificant. The estimated financial tradeoff between timber payment methods was $323.06 higher for consumer-scale sales. The average gross timber sale revenue from a SLCLD timber sale was approximately $520.95 per acre (Table 4). Therefore, the SLCLD recovered the additional cost of utilizing the consumer-scale payment method by selling 13.9 cords or 0.62 acres per sale (average acre of an SLCLD timber sale is approximately 22.4 cords [SLCLD dataset]). This highlights the relatively small financial impact of utilizing the consumer-scale method versus the SOAV method.

Public agencies must decide whether the cost savings of using the SOAV timber payment method (i.e., $323.06 per timber sale) outweighs the non-financial benefits of the consumer-scale timber payment method. Therefore, when a public agency is selecting a timber payment method, it might be in the agency's interest to focus on the non-financial impacts of timber payment method selection. Since timber payment method does not significantly influence gross timber sale revenue or total administrative cost, public agencies might consider giving buyers the option to choose their timber payment method at the auction. The SLCLD frequently offers timber sales with the option to choose timber payment method. Increasing the use of that option might result in higher bidding activity if buyers know that the public agency allows for some flexibility in method of payment. In summary, the financial impact of the two timber payment methods on a public timber program's cost-effectiveness is relatively small, and future research might focus more on the non-financial benefits and costs of each timber payment method.

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Appendix A. Example timber sale offered by the SLCLD

Tract # 1	TACONITE PINE							Sale Administrator: Nick Hoff
French Township	Number of Blocks: 1						NE1/4 SE1/4, W 1/2 SE1/4, Sec. 9, Twp. 60N Rge. 21W	
Virginia Area	Total Acres: 44.5							
C19150001	Season of Operation: August 1 - March 10						47° 41' 44.611" N 93° 0' 20.574" W	Expires: 4/15/2018

Product	No Bid	Block1	Block2	Block3	Block4	Block5	Block6	Total Volume		Appraised Value		Total Value
Aspen pulpwood	61							61 Cords	@	$5.00	=	$305.00
Balsam Fir pulpwood	9							9 Cords	@	$5.00	=	$45.00
Birch pulpwood	9							9 Cords	@	$5.00	=	$45.00
Jack Pine pulpwood	29							29 Cords	@	$5.00	=	$145.00
Norway Pine pulpwood	595							595 Cords	@	$10.00	=	$5,950.00
White Pine pulpwood	19							19 Cords	@	$5.00	=	$95.00
White Spruce pulpwood	2							2 Cords	@	$5.00	=	$10.00

Down Payment Required (15%): $989.25   Total Appraised Value: $6,595.00

Comments:

Either cut-to-length or skidding equipment with a maximum width of 12 feet must be used.

Use your smartphone to scan the QR Code for access to maps, cutting regulations, contract information and special regulations, or visit our website.

St. Louis County
TACONITE PINE

* ALL SKID TRAILS WILL BE CUT 15' WIDE WITH LEAVE STRIPS 40' WIDE. Designated thinning width's have spatial marks for a width guide, they are referenced with paint located on trees 55' apart.

*TO ACHIEVE DESIRED SPACING:
In block 1A & 1B, harvest all contract species in the skid trails only. In the leave strips, harvest ONLY RED PINE with a desired 11' X 11' spacing, Remove red pine with smaller diameters and poor form first (forks, crooks, double tops, sweep, etc.) to meet the spacing requirements.

BLOCK 1C LEAVE STRIPS,
First- Remove non-pine species
Second- Remove small diameter and poor form (forks, crooks, double tops, sweep, etc.) Jack pine, Red pine & White pine (in this species order) to a desired spacing of 14' x14'

Appendix B. SLCLD historic timber sales (price and volume), 2006-2012[1].

The historic timber sales data reported within the MN DNR stumpage price review and price index between 2006-2012 for the SLCLD. The timber products only included: pulpwood and pulp and bolts. Biomass, sawtimber, and fuelwood were not included in the annual volume and price estimates, as they were not reported for the SLCLD in most of the included years (2006-2012). There was some volume reported for sawtimber and biomass sold by the SLCLD, but it was insignificant and did not change the results. All of the SLCLD volume below was reported in cords.

Annual volume harvested in cords

Species	2006	2007	2008	2009	2010	2011	2012
Aspen	81,814	81,044	92,994	94,295	86,063	89,217	84,566
Birch species	29,444	23,386	24,443	29,351	23,087	22,295	-
Ash species	5,918	7,837	2,692	7,882	5,777	19,749	2,939
Oak species	-	-	147	-	30	537	137
Basswood	545	649	2,810	956	1,888	644	983
Other hardwoods	10,551	-	-	-	-	-	-
Balsam fir	22,535	15,239	16,800	18,893	20,340	23,887	21,114
Spruce species	28,410	26,170	23,825	22,791	26,281	24,679	27,514
Tamarack	6,436	2,753	3,475	8,962	4,945	3,201	4,137
Jack Pine	5,965	3,972	4,150	4,563	6,766	2,998	3,154
Red & White pine	2,148	3,778	7,542	5,381	6,758	4,945	5,576
Maple	-	7,154	16,648	15,247	12,052	12,833	12,211
Total	193,766	171,982	195,526	208,321	193,987	204,985	162,331

[1] **Source**: MN DNR stumpage price review and price index (2006-2012).

SLCLD average annual sale volume by species, 2006-2012.
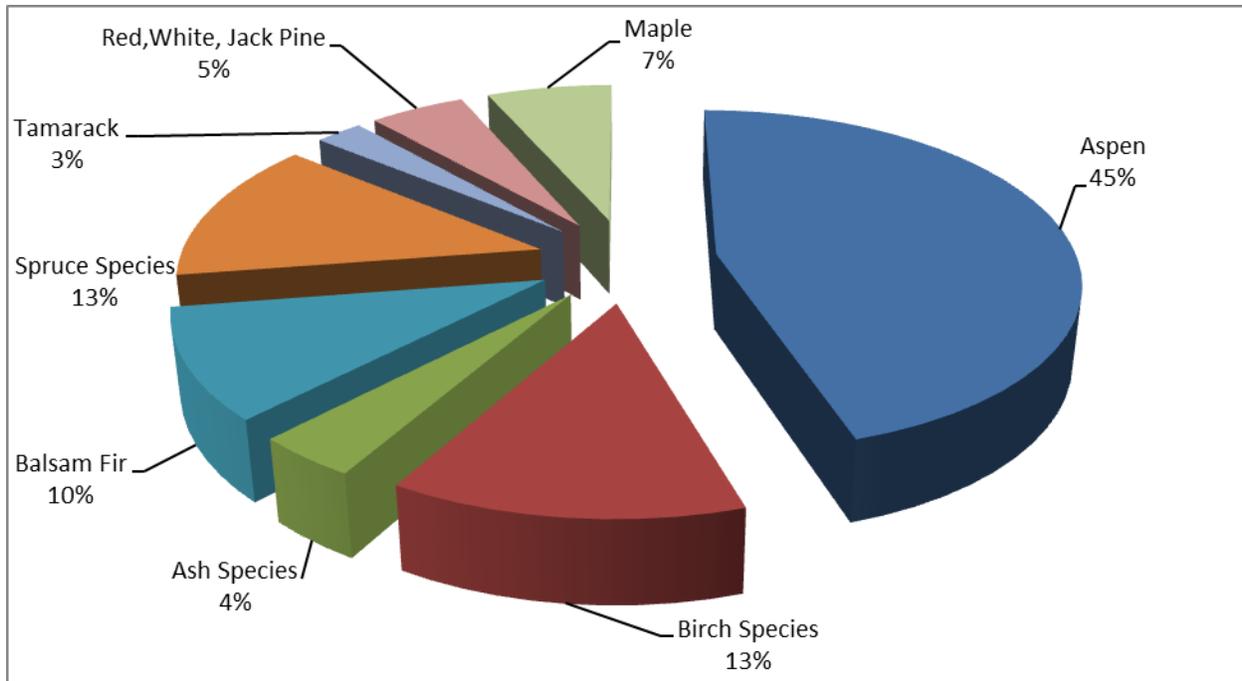
Average stumpage price by species ($/cord)

Species	2006	2007	2008	2009	2010	2011	2012
Aspen	56.06	30.50	29.32	26.21	28.74	27.90	28.96
Birch species	16.28	9.83	11.38	10.26	10.29	10.56	
Ash species	7.11	7.28	5.56	11.51	5.22	4.52	5.94
Oak species			5.31		6.15	23.59	11.69
Basswood	12.90	11.32	7.41	8.92	9.67	9.23	7.91
Other hardwoods	9.20						
Balsam fir	35.18	18.32	19.09	16.41	18.31	20.61	18.12
Spruce species	54.53	29.70	28.01	23.84	29.00	28.68	26.46
Tamarack	12.19	5.32	6.36	6.63	6.75	8.71	5.12
Jack Pine	38.38	28.20	24.18	23.78	28.20	43.95	23.33
Red & White pine	59.73	34.97	36.50	27.24	24.35	41.64	41.93
Maple		7.30	8.69	6.98	9.16	7.79	7.78

[1] **Source**: MN DNR stumpage price review and price index (2006-2012).

Appendix C. Notice of sale for the paired bidding experiment conducted by the SLCLD on February 20, 2014.

Cost-effectiveness of SOAV vs. Consumer-scale Timber Payment Methods Study Sites Bidding Instructions

January 13, 2014

Dear Prospective Buyer,

The St. Louis County Land and Minerals Department is participating in a study to evaluate the cost-effectiveness of SOAV vs. Consumer-scale Timber Payment Methods. As a part of this study, we are offering a select number of tracts that will be a part of this study.

NOTICE: There is an unusual bidding procedure for this sealed bid auction. Due to the nature of the study, some tracts will be offered in pairs. Both tracts in a pair are the same forest stands (acreage, volume, species and location), but are offered with different payment options. An eligible bid <u>must</u> provide a valid bid for each tract in a pair, i.e. a separate bid for each tract. Through a random selection process, only one tract in each pair will be sold. The highest bidder for that tract will be awarded the sale.

A $300 bid bond, i.e. personal check, payable to the **St. Louis County Auditor** is required and must be included in the bid envelop. One bid bond will cover all tract bids (including the Special Study Site Tracts) and will be returned if there are no successful bids. For a successful bidder, the bid bond will be applied to the down payment on the first tract awarded.

Instructions for bidding on pairs of tracts:

1. Paired tracts are grouped together on the sealed bid form and labeled Tract #A, Tract #B. [Tracts A will be offered as SOAV, Tracts B will be offered as Consumer Scale].

2. Complete the bid form for each tract in the pair. **You must bid on both tracts in a pair for your bid to be accepted.**

3. Return completed bid forms in the provided bid envelop by the closing date specified in this auction booklet.

Please follow the above directions carefully if you intend to bid on one of the study tracts. If a bid is received for only one tract in a pair, it will be considered invalid.

Thank you for your participation in this study. If you have any questions regarding this sealed bid auction, please contact Mark Reed, Deputy Land and Minerals Director at 218-726-2606.

Sincerely,

Mark Weber
Land and Minerals Director / Land Commissioner

Appendix D. Sample paired bid auction form used during the February 20, 2014 paired bid auction conducted by the SLCLD.

Tract 1 Version A: <u>Lump Sum</u>			**$16,684.47**
Species	**Estimated Volume**	**Appraised Value per unit**	**Bid Value per unit** [Must meet or exceed appraised value per unit]
Aspen pulpwood	500 cords	$15.90	
Balsam fir pulpwood	245 cords	$9.29	
Birch pulpwood	590 cords	$4.54	
Red maple pulpwood	35 cords	$2.67	
Norway pine pulpwood	119 cords	$26.93	
Black spruce pulpwood	10 cords	$15.67	
White spruce pulpwood	25 cords	$13.00	
All species for Tract 1 Version A are sold as Lump Sum EXCEPT FOR NORWAY PINE. If bidding on this tract, you must also submit a bid on Tract 1 Version B below.			
Tract 1 Version B: <u>Consumer Scale</u>			**$16,684.47**
Species	**Estimated Volume**	**Appraised Value per unit**	**Bid Value per unit** [Must meet or exceed appraised value per unit]
Aspen pulpwood	500 cords	$15.90	
Balsam fir pulpwood	245 cords	$9.29	
Birch pulpwood	590 cords	$4.54	
Red maple pulpwood	35 cords	$2.67	
Norway pine pulpwood	119 cords	$26.93	
Black spruce pulpwood	10 cords	$15.67	
White spruce pulpwood	25 cords	$13.00	
All species for Tract 1 Version B are sold as Consumer Scale EXCEPT FOR NORWAY PINE. If bidding on this tract, you must also submit a bid on Tract 1 Version A above			

Appendix E. SLCLD administrative time information.

There were five administrative tasks in the ticketing process: (1) stamping and mailing, (2) opening and recording, (3) entering data, (4) closing the sale, and (5) billing and refunds. The first four tasks were recorded by SLCLD area office staff (area administrators) and the fifth task was recorded by the SLCLD downtown office staff person (downtown administrator). The area offices are located in Pike Lake and Virginia, and the downtown office is in Duluth, MN. The dataset below is the information used for estimating the ticket processing cost in section 3.2.

The time spent on tasks 1-3 was recorded by SLCLD area administrators during the following periods: July 30, 2013, to August 30, 2013, and February 5, 2014, to March 5, 2014. The first time period was used to test the data collection process, and the second time period was used to ensure that data was collected during the busiest time of the year in order to obtain as much time study information as possible. The time spent on task 4 (sale closing) was separately recorded by SLCLD area administrators on a total of 15 sale closings that occurred between August and November 2014. SLCLD area administrators also recorded the time spent working on "problem tickets" during August 2013 and February 2014 (same period as tasks one to three), which was incorporated into the total cost of administering a consumer-scale ticketing system. To gather the information needed for tasks 1-4, each area administrator recorded the minutes they spent each day (observation) processing tickets by task, as well as the total number of tickets processed that day.

Days	Minutes					Total Tickets
Observation	**Task 1** **Stamping**	**Task 2** **Opening**	**Task 3** **Entering data**	**Task 4** **Closing**	**Problem** **Tickets**	**Tickets** **processed**
1	10	65	0	0	6	315
2	5	11	0	0	0	56
4	0	7	0	0	0	27
5	5	0	90	0	39	127
6	0	21	140	0	0	339
7	0	3	0	0	1	20
8	0	37	20	0	2	205
9	0	1	0	0	0	1
10	0	6	55	0	0	90
11	0	3	0	0	0	13
12	5	11	0	0	0	90
13	9	7	35	0	0	134
14	0	0	75	0	0	117
15	0	2	24	0	0	32
16	0	10	0	0	0	35
17	0	8	40	0	0	46
18	0	10	0	0	0	22
19	0	5	46	0	0	144

20	3	10	32	0	0	103
21	0	4	0	0	0	12
22	0	38	0	0	0	166
23	5	4	15	0	0	73
24	5	0	50	0	0	121
25	0	18	0	0	0	87
26	0	12	0	0	0	37
27	0	0	109	0	0	151
28	0	1	109	0	0	164
29	7	10	47	0	0	104
30	10	42	0	0	0	206
31	15	0	0	0	0	110
32	0	0	0	0	30	2
33	20	16	0	0	0	100
34	0	8	0	0	0	23
35	5	0	0	0	0	50
36	0	0	0	75	0	17
37	0	0	0	85	0	46
38	0	0	0	10	0	7
39	0	0	0	30	0	78
40	0	0	0	155	0	69
41	0	0	0	40	0	17
42	0	0	0	51	0	37
43	0	0	0	75	0	68
44	0	0	0	70	0	216
45	0	0	0	120	0	58
46	28	0	0	0	0	117
47	0	0	0	0	15	25
48	0	0	0	0	25	21
49	1	0	0	0	0	46
50	0	0	0	0	15	46
51	22	0	0	0	0	126
52	24	0	0	0	0	115
53	0	0	0	0	10	1
54	0	0	0	0	10	1
55	2	0	0	0	0	14
56	32	0	0	0	0	227
57	0	0	0	0	3	1
58	14	0	0	0	0	163
59	5	0	0	0	0	58

60	34	0	0	0	0	344
61	0	0	0	0	1	1
62	0	0	39	0	0	96
63	0	0	10	0	0	7
64	0	0	35	0	0	115
65	0	0	40	0	0	105
66	0	0	5	0	0	3
67	0	0	27	0	0	77
68	0	0	17	0	0	42
69	0	0	1	0	0	1
70	0	0	50	0	0	140
71	0	0	0	260	0	308
72	0	0	0	85	0	205
73	0	0	0	20	0	92
74	0	0	0	65	0	109
75	0	0	0	65	0	76

Appendix F. Description of the tasks associated with SLCLD's ticketing process

Tasks 1 – 4 were conducted by the SLCLD area administrators and task 5 was conducted by the downtown administrator. The following information provides detail on each task within the process.

Task 1: Stamping and Mailing
SLCLD area administrators stamp the contract number on each ticket booklet and write the name of the sale and buyer on the outside of each booklet. Before the booklets are ready to send out, administrators manually record the date, contract number, sale name, buyer, forester's initials, and ticket numbers into the "Load Ticket Dispersed Binder".
The booklets are then sent out to the buyer.

Task 2: Opening and Recording Tickets
As each load is scaled, the consuming mill attaches the corresponding load ticket to a mill "scale sheet" and sends information to the SLCLD office. Once the office receives the information from the mill, the area administrator sorts each load ticket and the attached mill scale sheet by contract number. The area administrator then manually records scale information into the "Load Ticket Ledger Binder".

Note: The "Load Ticket Dispersed Binder", described in Step 1, serves as a "checks and balances" system for the returned ticket/mill sheet information, which is recorded in the "Load Ticket Ledger Binder". During the closing of the sale, the administrator uses these two binders to check for missing or unused tickets.

Task 3: Data Entry

Once enough tickets have accumulated across multiple timber sales, administrators enter all load information into the database. As each contract is completely entered into the database, the database prints out a report with total volumes for each species. The total volume by species from these reports is then recorded into two worksheets called, the "field file" and "area file".

After recording the information into the "field file" and "area file", the administrator archives the load tickets and scale sheets at the Area offices.

Task 4: Closing the Sale

The steps to prepare the documents for closing the sale include the following:

1. Compare all information between the "field file" and "area file".

2. Note the number of harvest inspections, payment amounts, and method of payment.

3. Review harvest inspections for any information that may pertain to timber charges.

4. Compare tickets issued in the "Load Ticket Dispersed Binder" to the tickets returned in the "Load Ticket Ledger Binder". If any tickets are missing, a missing ticket letter

is sent out, which informs the buyer that he/she has 30 days to provide the missing tickets and scale sheets.

5. Review the tickets and scale sheets to check for chipped wood volumes.

6. Check for any mixed specie loads

7. Enter any SOAV volumes (appraised) and added volumes into database

8. Enter total volumes, species, products, and unit prices by block and by entire sale into database

9. Send out the "field file" and closing papers for a quick internal review (reviewer looks for trends in specie composition). Once the internal review is completed, the field files are sent to the forester for review. After forester approves the paperwork, the file is returned to the area office. Internal and forester reviews may take up to one week before they are returned to the area office.

10. Email closing papers to the downtown office.

Task 5: Billing and Refunds

A final statement is issued at the downtown Duluth office for both SOAV and consumer-scale sales.

1. The time spent on SOAV sales is the repayment of the down-payment (deposit) to the buyer. Sometimes the deposit is applied to the final block in a multi-block sale, and the administrator has to reconcile difference before closing the sale.

2. The time spent on Consumer-scale sales is billings and refunds. The downtown administrator refunds the payments that were less than the appraised volume for a given species and bills the buyer if the final harvest was more than the appraised volume.

*Problem Tickets:

Time spent on "problem tickets" can occur at any point in the ticketing process, but in order to keep the processes moving, the "problem tickets" are set aside for the area manager and entered into the database at a later time. The additional time spent on "problem tickets" is typically due to one of the following reasons:

1. Incomplete/blank tickets require the area manager to decide whether to penalize the buyer, and if a penalty occurs, then additional time is spent issuing and signing a penalty letter.

2. Adding culled volumes to reported net weights – mills may discard a portion of a delivered load, but this culled volume must be added back to the gross weight to derive a total net weight per load.

3. Resolving conflicting information between load ticket and mill scale sheet (i.e., contradictory contract numbers, specie discrepancies, inconsistencies in the scaled dates).

Appendix G. **Summary of SLCLD scaling types in 2014.**

The following table below shows the calendar year 2014 scale data obtained from the SLCLD. It shows that the vast majority of volume on consumer-scale sales was determined by the consuming mill (i.e., 95%). The in-woods scale type were volumes that were scaled by SLCLD staff. The data contains the volume that was sold and scaled by the SLCLD in 2014 (148,272 cords out of the 186,866 cords sold [MN DNR – Forests, 2014]). The remaining volume that was not scaled was sold using the SOAV timber payment method, which does not require scaling.

Scale Type	Number of Agency Scales in 2014 (cords)	Volume (cords)	Percent of Total Scaled Volume
Consuming mill	1,830	141,368	95%
In-woods	305	6,904	5%

Appendix H. SLCLD timber cruise information and the associated amount of time to cruise and walk between plots in 2008-2014

The charts below include more detailed information on SLCLD timber cruising time calculations. Chart 1 gives the annual number of plots and appraised acres to calculate the plots per acre, and the data from Chart 1 was obtained from Tom Zeisler of the SLCLD on April 10, 2015.

After collecting information on annual number of plots, four field foresters from the SLCLD and MN DNR who cruise timber were interviewed over the phone to estimate the approximate time spent per plot and traveling between plots. Chart 2 shows the estimated range of time spent cruising timber within sample plots with intervals of 3, 5, and 7 minutes per plot. Chart 3 is the estimated amount of time spent traveling between sample plots, assuming 3, 4, and 5 minutes of travel time between plots, as estimated by the SLCLD and MN DNR administrative staff. These time estimates were also discussed with SLCLD timber cruising administrators.

Chart 1. Annual number of plots, acres appraised and plots per acre associated with timber cruising in the SLCLD, 2008-2014.

Year	Number of plots	Appraised Acres	Plots/Acre
2008	8,843	9,155	0.97
2009	7,986	10,081	0.79
2010	7,480	8,417	0.89
2011	7,842	9,136	0.86
2012	7,528	8,505	0.89
2013	8,290	9,247	0.90
2014	8,351	7,617	1.10
Average	**8,046**	**8,880**	**0.91**

Chart 2. Annual number of sample plots that were timber cruised in 2008–2014 by the SLCLD and the estimated amount of time in minutes required to cruise those plots, assuming 3, 5 and 7 minutes per plot.[1]

Year	Number of plots	3 minute	5 minutes	7 minutes
2008	8,843	26,529	44,215	61,901
2009	7,986	23,958	39,930	55,902
2010	7,480	22,440	37,400	52,360
2011	7,842	23,526	39,210	54,894
2012	7,528	22,584	37,640	52,696
2013	8,290	24,870	41,450	58,030
2014	8,351	25,053	41,755	58,457
Average minutes		24,137	40,229	56,320
Average hours		**402**	**670**	**938**

[1] The time estimates are based on a phone survey of four field foresters who conduct timber cruising in the SLCLD and MN DNR.

Chart 3*:* Annual number of plots that were timber cruised in 2008–2014 by the SLCLD and the estimated amount of time in minutes to walk between the plots, assuming 3, 4, and 5 minutes of walk time between each plot.[1]

Year	Number of plots	3 minutes	4 minutes	5 minutes
2008	8,843	26,529	35,372	44,215
2009	7,986	23,958	31,944	39,930
2010	7,480	22,440	29,920	37,400
2011	7,842	23,526	31,368	39,210
2012	7,528	22,584	30,112	37,640
2013	8,290	24,870	33,160	41,450
2014	8,351	25,053	33,404	41,755
Average minutes		24,137	32,183	40,229
Average hours		**402**	**536**	**670**

[1] The time estimates are based on a phone survey of four field foresters who conduct timber cruising in the SLCLD and MN DNR.

Chart 4. Total estimated times to cruise timber within sample plots[1] and walk between plots in 2008-2014 by the SLCLD[2].

Year	Lower estimate (6 minutes)	Middle estimate (9 minutes)	Upper estimate (12 minutes)
2008	53,058	79,587	106,116
2009	47,916	71,874	95,832
2010	44,880	67,320	89,760
2011	47,052	70,578	94,104
2012	45,168	67,752	90,336
2013	49,740	74,610	99,480
2014	50,106	75,159	100,212
Average estimated minutes	48,274	72,411	96,549
Average estimated hours	**804.6**	**1,206.9**	**1,609.1**

[1] The lower, middle, and upper estimates are the combined results from Charts 2 and 3.
[2] The time estimates are based on a phone survey of field foresters who conduct timber cruising in the SLCLD and MN DNR.